STUDIES ON WILT DISEASES OF ORNAMENTAL TREES

THESIS

Submitted for the degree of

DOCTOR OF PHILOSOPHY
IN SCIENCE

TO THE
UNIVERSITY OF ALLAHABAD

BY

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DEDICATED

TO

MY

BELOVED

PARENTS

Certificate

Certified that the thesis embodies results of original research work and study carried out under my supervision by Mr. Akhandeswar Pratap Singh.

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PREFACE

The thesis embodies research work **on "Study on Wilt Diseases of Ornamental Trees"**. The work carried out by me from Dec. 1996 to June 2002 in the Someshwer Nath Bhargava Agricultral Botany Laboratory, Botany Department, University of Allahabad. A comprehensive survey of Allahabad and its adjacent regions was made.

The thesis embodies researches with studies on some *Fusaria* isolated from various ornamental, wilted trees.

The thesis is compiled into Ten Chapters. First chapter deals with Introduction followed by Materials and Methods (Chapter – 2). Isolation and Pathological Studies are discussed in Chapter – 3 and chapter – 4. Environmental Studies, Survival Studies are given in Chapter 5 and Chapter - 6. Control Studies is discussed in Chapter – 7. Discussion is given in Chapter – 8. The whole work is summarized in Chapter- 9 as Summary. The References containing the references cited in the text is appended in the end. (Chapter 10). Abstract of the present work is also submitted along with the thesis separately.

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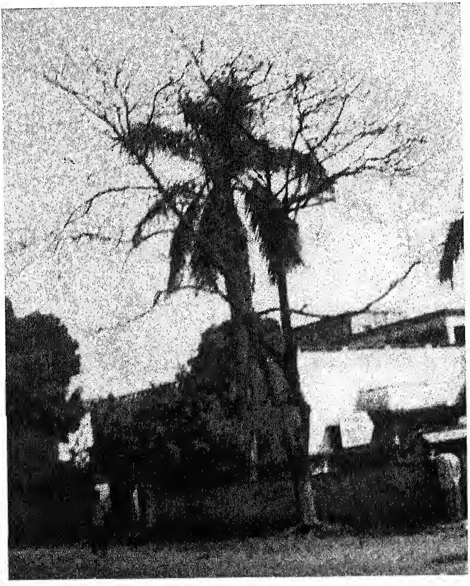
CONTENTS

CHAPTER – 1

INTRODUCTION



Introduction

"Let the earth and the water, the air and fruits of my country be sweet my God.

Let the homes and the marts, the orchards and the fields of my country be full of my God."

- Ravindra Nath Tagore.

Life on the earth has originated because of very complicated inorganic and organic evolution. It is due to these complex interaction reductive atmosphere of primitive earth became oxygenative. Green plants due to their photosynthetic activity liberated free oxygen and pave the way for the origin of animal bio-diversity as a complementary life form. Plants and animals are so interactly interdependent on each other that one can not exist in absence of the other.

It is the plant community which is a source of almost all essential items which is required for our sustinance such as food, fodder, fuel, fruit, pharma etc.

Besides these essential commodities plants act as green signal for the survival of all life form on the earth. It gives colour to our life and surrounding nature. Area devoid of plants look deserted and appears to be a graveyard. Esthetic value of flowering plant is evident in the great epics of Kalidas such as Meghdootam and Kumar Sambhaw where it seems that it is

the inspiration of plants that motivated the poet to reflect his thoughts in his creation in a very marvelous and heart touching order.

India being a mega diversity zone is blessed with a vast treasure ornamental and meditional flowering plants. Some of these plants are endemic to India and thus we should feel proud of having it in our mother land. These exclusive species originated in our country because of its unique environmental and meteorological characteristics. In fact these plants are the real certification of the unique features that has blessed by nature to our country. It is therefore these plants deserve especial attention for their conservation.

Impact of excessive exploitation of natural resources by the ever growing population and changed environmental condition is a real threat to the existence of some of these rare plant species. It may be possible that our negligence in this direction could result the extinction of these plant. In fact we cannot afford such a irrepairable loss.

Keeping the above mentioned significance of flowering plants in mind, attempts have been made in the present research work to find out the factors responsible for the loss of these plants due to some common fungal pathogens.

The developing countries are confronting with certain very complex and intricate issues related to population, Conventional approaches to deal with these problems are not competent enough to find out its solution, particularly through the application of science and technology.

The cross disciplinary knowledge of environmental science is taking its shape admist of our traditional significance of afforestation as a tool for social change is being realized and the concept of Joint Forest Management (JFM) education set up to face the challenges of the future. The is though to be an effective mode of development. which can ensure the process of sustainable development particularly in the developing countries.

Integration of ecology, economics and ethics in our Joint Forest Management approach could facilitate transfer of technology from the developed countries on a reasonable cost and conditions.

Plants are nothing but a green signal of existence not only to man but also to all forms of life present on this earth, therefore-

"Plant, plants for a perpetual peace."

Plants have been esthetically important to people since early civilizations. They have been held in high esteem by the Egyptians Phoenicians, Persians, Greeks, Romans Indians, and Chinese and some even worshipped them, with the fast growth of cities the importance of urban trees or urban forestry is becoming more important with this aim the management and protection of urban trees is discussed to meet the social needs and also to minimize the conflict with utility services.

The migration of people from country side to cities in search of employment opportunities is a world wide phenomenon. Consequently the cities have been growing bigger and bigger every day. The fast growth of cities is putting extreme pressure on land use and the consequent

construction of high rise building and apartments is converting cities into jungles of concrete and cement. During mid 1800's the landscape concept developed in cities as a result of increasing industrialization. It was also used in the development of suburbs to allow an escape to areas of natural beauty.

In India we have neither an official recognition nor organisational set up to look after the problems of city trees, which is very much needed to maintain these as well as for climatic amelioration, pollution problems, and esthetic value and clean air.

The management of urban trees calls for to meet the objectives of the owner and the beneficiary (the general public). Trees in the community, suburban and urban areas are planted generally due to their positive implications on the overall global environment.

The significance of plants has been glorified not only by scientists but also by the thinkers of other disciplines, since the time immemorial.

According to the Oparin theory of origin of life, the life has originated in the water after a long chemical and physical changes on the primitive earth. The gradual stabilization of the environment of the earth allowed the evolution of initial procaryotic cells into an organism which bifurcated its behaviour and ultimately established into two well defined kingdoms, the Plant Kingdom and the Animal Kingdom. It is because of their common origin point and evolutionary course, plants and animals are the two inseparable and interdependent life forms and one can not exist in absence of the other particularly the latter one.

In the race of evolution plant defeated the animals as they developed the mechanism of photosynthesis which enabled them to capture the radiant energy of the sum to change and store them into chemical energy. This enigmatic capability allowed them to propagate much faster that the animals and the entire earth became green due to their presence in abundance.

Interaction with changing environment and adaptation of existing flora fauna accordingly became the guiding factor for the balanced evolution of different king of ecosystem for their perpetual existence. The nature was empowered to maintain eco-balance even though the cruel means of elimination and destruction. Life forms have always opposed the cruel approach of nature to maintain the balance among the different components of an ecosystem. Power and ability of adaptation enabled them to cope with the situation to the some extent even then a number of them could not survive against the supreme commander of their destiny and are available to us in their fossil forms. Extinction of speciesbecame a part of evolutionary process of the life. The quest to fight with nature for survival blessed us a brain with a tremendous power of analysis and data storage. Preplanning of future with the help of a developed mind placed us at a distinct position from merely brain bearing animals.

Population and environmental nexus needs a serious consideration on the loss of green gold from the treasure of the nature. Under to agenda 21 deforestation and afforestation nexus is being dealt with due care even then today it is the demand of the hour to universalize the knowledge of Ecological-evolution and Evolutionary-ecology up to the grass root level.

Only afforestation is the answer to this complex challenge mentioned in the priorities of the agenda of the next century i.e. agenda 21 of the earth summit.

Science and technology generated pollution and deforestation problem could be solved through the appropriate application of ecotechnologies to a great extent. Technological advancement of the west in association with their partners in the east can participate in operation of green industries.

Due to their vast distribution in almost all type of geo-climatic conditions, plants have developed a tremendous potential to survive even in very adverse environmental conditions. Only 2% of the total plant species have been scientifically named and identified so far. It is possible that due to our ignorance and extensive rate of deforestation some of these natural treasure may be vanished forever before we know their utility for the welfare of mankind.

Plants act as a minerals bio-pump. They play a very significant role to take out deep seated nutrients through their extensive root absorption zone and mix them into top soil, therefore, they play a very important role in the natural nutrient cycling, which is very essential to maintain the fertility potential of the top soil. Some plants have capability to fix the free atmospheric nitrogen into the soil. Therefore, plants can be regarded as an integral part of carbon, nitrogen, oxygen and other mineral cycle of the nature. The increased percentage of carbon-di-oxide in the atmosphere can only be balanced through an extensive afforestation programme. As a long hair of Lord Shia, the roots of the plant on the hill slopes protect the top soil

to get washed away through rain water run off and a major portion of water gets a chance to enter in the hydrological cycle of the area therefore, these plants protect us from recurring floods in rivers.

Some plants while growing in a polluted water absorb the pollutant and make it pollution free. Such hydrophytes play an important role to maintain the ecological balance in the aquatic ecosystem and they provide much needed oxygen to the aquatic fauna.

Plantation at the road and railway line sides absorbs the noise and suspended air particle thus helps in protecting the near by areas from such pollution.

There are a number of plant species which can tolerate high an low pH of the soil and therefore can grow profusely in an alkaline and saline soil conditions. Such plant varieties plays a significant role in waste land reclamation of affected soils.

There are several plat species which are being used in agroforestry and social forestry programmes. Through such type of plantation we can easily ensure the public participation and in turn it will provide employment as well as required food, fuel and fodder to the local public.

All living being takes oxygen during respiration and give out carbon-di-oxide. If this process continues, all the oxygen of the atmosphere will be used up. The green plants give out oxygen as a by-product in photosynthesis. Thus plants maintain the oxygen balance in the nature therefore, they could be regarded as the green lungs of the earth.

From time immemorial plants are associated with our life. We have appreciated the exquisite beauty of the world of plants through generations and trees are undoubtedly the most prominent group. Tree is a woody plant with a spreading crown, whose single trunk exceeds diameter of 15 cm. and attains a certain height. All trees are capable of producing seeds under favourable environmental conditions and grow vigorously for many years.

A tree may show the height and shape of a shrub in a climatic condition- different from the natural habitat and temperature, light, humidity and moisture and nutritional status of the soil are found to play important role on growth and flowering of plants.

Hundreds of thousands of persons in this country grow plants for the adornments of their homes, and other thousands produce ornamental plants commercially. The cultivation of beauty has a real function in civilized life - even in time of war, as the English have shown. The importance of gardening as a hobby scarcely needs emphasis. It also has a therapeutic value, well known in institutions which care for the mentally diseased. In growing plants one of the principal wars to be won is that against disease and pests.

Trees are very fascinating because of their graceful appearance and the abundance of bloom. They are grown for their economic importance or aesthetic value of both. Fruit trees are planted for fruits and forest plantation for the other economic products like timber, fuel, tannins, oils, gums, resins waxes, spices, beverages, narcotics and drugs.

The conspicuous or pretty flowers framed against the panorama of sailing clouds attune us with nature's rhythms and boundless joy at flowering time. A large number of trees in our country are resplendent n riotous colours at the flowering time and are capable of transforming the landscape.

The tree are the most important elements in landscape and thorough knowledge of their ornamental properties, rate and mode of growth, their behaviour in different soil, situation and climate are essentital, they should be planted carefully and thoughtfully for the benefit at height, shade, colour and vertical emphasis.

Avenue trees are beautiful and safety enchanting feature of modern roads, reduce head light glare from the oncoming traffic and provide a more pleasant drive with. less distractions from the surroundings. Mostly indigenous shade and flowering trees are widely selected for landscaping these medians, where the traffic lanes are widely separated, rest parks with groves of trees have been provided.

We have got large number of indigenous and exotic flowering trees which can be successfully utilized to beautify our cities, towns and villages. Along with the road plan, a plantation plan should be made and strictly adhered to. For the existing roads the dead and decaying trees should be replaced systematically according to a plan. Beautifully planted avenues with flowering trees are prettly with the colour and beauty. The trees should not be patchy due to lack of aesthetic sense of those maintaining the roads. Delonix regia, Anthocephalus indicus, Cassia nodosa, Bauhinia purpurea will add colour and charm to an avenue. But shade and economicutility

should be the main criterion for highways and Lagerstroemia speciosa, Tamarindus indicus, Mangifera indica, Swietenia mahagoni should be selected. One type of tree should be planted for a considerable length to provide a beautiful skyline and uniform crown but not in mixed patches.

Colour of the flowers is an important factor to consider in the selection of trees.Primary colours like red, yellow, blue and secondary colours like orange and purple show a very effective display. Green is also a secondary colour and the subtle tertiary colours derived from mixtures of these colour are also very attractive. Scarlet flowers of Spathodea companulate Lagerstroemia and Jacaranda look brightest in the grey asphalt roads. The power and effect of contrast colours should be kept in mind while planning tree planting. Many trees in our country burst into gorgeous blooms at a particular season, the colour of their flowers harmonize and appear more effective when planted in groups. Cassia fistula, Delonix regia, Peltophorum ferrugineum, Lagerstroemia speciosa, Cassia nodosa all bloom in May. The rich yellow contrasting with scarlet and deep mauve or pink form a striking colour scheme.

Many trees burst into bloom beautifully, while others afford a pleasing contrast with their decorative foliage. Although we have an abundance of flowering trees, selection of trees for private gardens which should create rhythm, accent, as well as balance in the garden and the dwelling place is rather difficult.

In small or medium gardens ornamental trees should be planted onlyin the boundaries as foundation planting and one small tree like

Callistemom,Bauhinia variegata, Amherstianobilis as an accent near the building. The knotted Neem or crowded growth of mango, gauava or jackfruits produce ugly effect and make the most modern looking building look gloomy and depressing. The fruit trees should be planted to the back portion of the house where theyare not visible from rthe entrance. A row of Polyalthia pendula often makes the approach road to the house very attractive. A group of Plumeria or Cassia at the boundaries charm and grace to the house.

Many trees in India are actually natives of other countries. *Cryptomerial japonica,* the common conifer of Darjeeling hasbeen introduced from Japan in the eighteenth century. Many beautiful trees from other tropical countries have been introduced by the British explorers and Missionaries. *Delonix regia,* were brought from Madagascar; *Brownea, Guaiacum* from West Indes; *Enterolobium saman, Erythrina cristagalli, Coroupita gianensis* were introduced from tropical America. Australia with its diversified plant life, is the native home of many ornamental trees like *Acacia auriculiformis, Eucalyptus citridora, Callistemom lanceolatus, Melaleuca leucadendron* and *Greveillea robusta. Spathodea campanulata, Kleinhovia hospita* are native of tropical Africa. Most of the pink Cassia and *Pterocarpus indicus, Saraca declinata* have been introduced from Malay and Java, *Amherstia nobilis* is a native of lower Burma.

List of our indigenous ornamental trees will be very long and it includes many colourful flowering trees like *Butea monosperma*, *Bauhinia purpurea, Cassia fistula, Lagerstroemia speciosa, Cochlospermum*

gossypium, Bombax malabaricum, Millingtonia hortensis, Dillenia indiaca and *Saraca indica.* Trees with ornamental foliage indigenous to India include *Polyalthia longifoila, Purtanjiva roxburghii, Mimusops elengi* and *Azadirachta indica.*

Acacia auriculfiformis (Golden shower) is an evergreen tree of graceful appearance which is said to have been introduced from Australia. The tree reaches to a height of about 20m with waxy green, rather thin rounded crown. The tree grows quickly in tropical and sub-tropical regions in all types of soil. It is planted on road side, parks and large private gardens.

Adenanthera pavonina is a beautiful deciduous tree up to 20 metres tall, with uneven round crown; bark pale pinkish grey. Small creamy yellow flower are bone in 8-15 cm. long spikes at the axils of the leaves , March-April.

Amherstia nobilis is one of the most beautiful flowering trees of the world, an evergreen tree indigenous in *Tenasserium* and cultivated in the warm humid regions of Burma and India. Flowers are vermilion edged with yellows, appearing from March to May.

Azadirachta Indica (Indian liac, Margosa tree) is a medium sized almost evergreen tree usually maintaining a height between 10-15 m.The tree is very popular in India because of its high medicinal properties.

Bauhinia variegata is a small sized tree with dark brown and more or lesssmooth bark, reaching to a height of about 6-8 m. Flowers in cluster of 5-7 in a short raceme or corymb, 5 cm across, large, fragrant, beautifully

coloured with various shades of pink and purple appearing when the tree is leafless in February-March.

Bignonia megapotamica is an evergreen tree of medium size growing up to a height of 10 m and produces clusters of light mauve flowers. It is a quick growing tree in warm humid climate. The plant remains in bloom almost throughout the year but larger number of flowers develope from March to May.

Callistemon lanceolatus (Bottle Brush) plant is known is also known as "Bottle Brush" because the flower-bearing portions of the branches resemble bottle brushes in shape. Flowers in densely crowded cylindrical spikes 5 to 10 cm. long, with long scarlet stamens, projecting stiffy outwards. The tree has pendulous branches, often grown on road side and gardens.

Calophyllum inophyllum (Alexandrian laurel, Dilo oil tree) is a medium sized evergreen tree with smooth grey bark and cylindrical branches reaching a height of about 15 m. Flowers white, sweet scented 2 cm. diameter, in loose axillary racemes at the end of the branches from June to October.

Cassia fistula (Indian laburnum) is a medium sized deciduous trees reaching a height of about 8-10 meters, indigenous to India and cultivated in Tropical Aftica, South America and West Indies.

Cassia fistula is considered as one of the finest yellow flowering trees of the world. It is very popular in tropical India as road side tree and also commonly grown in gardens and parks.

Cassia marginata (Red Casia) is a small tree, with short trunk and drooping branches. The flowers are smaller, terracotta appear in small axillary branches in June-July.

Cassia nodosa (Pink Cassia) is a deciduous tree attaining a heigh of 12-16 m. distributed in India and many other countries such as Burma, China, Malayasia and Indonesia. Flowers are 2.5 cm wide, bright-ping fading to white, softly hairy, sweetly scented and appear in loose cluster along the branches during April-July.

Cassia renigera (Burmese pink Cassia) is indigenous to the dry zones of Burma and is now extensively grow in India and Malaya. It is a medium sized deciduous tree reaching up to 10-12 m in height with a short trunk and a few upright branches bearing numerous slender drooping branchlets. Flowers are arranged in bunches along the branches, bright pink in colour and appear in April-May.

Cochlospermum gossypium is small or medium sized, deciduous, soft-wooded tree reaching a height of about 6-8 m. Flowers large; 6-8 cm across, bright yellow in colour arranged in terminal panicles which appear after leaf fall from December to April.

Crataeva roxburhghi (Caper tree. Bengal quince) is a small deciduous tree of graceful appearance reaching a height of up to 10m, distributed

throughout the greater part of India and Burma, wild or cultivated. Flowers, creamy turning yellow, 5 cm. across appear in large cluster at the end of the branches. Flowering season is March-May.

Delonix regia (Gulmohar, Flame tree, Peacock flower) is a large deciduous tree, native of Madagascar and reaching a height of 12-20 m with spreading branches, umbrella shaped crown and greyish bark. It is one of the most beautiful and common flowering trees grown in India and very suitable for parks, roadside and also large private gardens.

Erythrina indica (Coral tree) is a tall deciduous tree reaching a height up to 18m; bark is smooth, yellowish or greenish grey. Flowers large, red 5 cm long, pea shaped in dense racemes 16-20 cm long which appear in February-May.

Eucalyptus citriodora (Lemon scented Eucalyptus) is a tall handome tree with slender tapering trunk usually attaining a height of about 40-50 m. Flowers small white in terminal corymb of 3-5 flowered umbels, arising abundantly in March-April. It is a beautiful tree of elegant appearance.

Eucalyptus globulus (Blue Gum) is a tall, erect tree with greyish or bluish white bark. The tree is a native of Australia and often grown in India for its graceful appearance and ornamental leaves.

Eucalyptus robusta (Swamp Mahagony) is a beautiful symmetrically branched tree. Bark persistent dark brown. Flowers small white, borne in clusters of 6-12 from near the base of the leaf. It is commonly grown in the gardens of tropical India.

Ficus bengalensis (Banyan) is a large evergreen tree, may attain a height of 30m, branches spreading, almost horizontal. The tree is indigenous near the foot of the Himalayas and Western India and is commonly plated all over the country.

Ficus elastica (Rubber tree) is a large tree with fairly smooth reddish brown bark. Leaves alternate, elliptic, coriaceous shining 12-20 cm. long.

The dark green glossy foliage is very handsome.

Ficus religiosa (Peepul) is a huge tree with greyish bark. Leaves smooth shining broadly ovate, apex long and narrow, 10-18 cm long. The tree is indigenous in Bengal and Burma and is cultivated all over India. Handsome dense foliage on the spreading branches gives a cool and pleasant shade under the tree.

Gardenia latifolia is a small tree, indigenous in Bihar and West of India. Flower large solitary, axillary, white fading yellow, fragrant; corolla tubular about 7 cm long, lobes expanded, 8 cm across.

This hardy plant should be grown more widely in parks and gardens.

Hibiscus populuneus (Portia tree, Bhendi tree) is a medium sized evergreen tree reaching a height of 7 to m with smooth grey and spreading uniformly. Flowers large, about 7 cm across axillary, at first yellow with purple centre, becoming entirely purple by evening.

Largerstroemia speciosa (The Pride of India, Crepe flower) is a deciduous tree of 16-20 m in height, a native of S, E, Asia. Large, beautiful

flowers are borne on long erect and stout spike 25-35 cm in length, arising from the end of the branches during April to June.

Magnolia grandiflora (Lily tree, Laurel magnolia) is a plant, which may reach a height of 20 m. or more in cool and humid climate.

Flowers creamy white, sweetly scented, more or less cup shaped, 16-20 cm across. Flowering takes place during the hot weather, and each flower lasts for 2-4 days.

Michelia champaca (Golden champa) is a medium sized tree, reaching a height up to 20m the rather cylindrical or conical crown is supported by a few bold upright limbs. Flowers yellow, scented 5 cm long, grow singly, each from the base of the leaves.

Polyalthia longifolia (Debdar, Mast tree, Indian fir) is a handsome evergreen tree indigenous to Ceylon and much cultivated in the garden and avenue in India and Burma. The height may reach up to 20-25 metres, the crown is conical in shape. A beautiful weeping variety of this tree name P. longifolia var. pendula is very popular in India. The branches and leaves droops steeply downward.

Pterospermum acerifolium (Kanak champa) is a large handsome evergreen tree native of the Himalayas, Assam and Burma. Flowers large, solitary or in pairs in the axils of the leaves, strongly fragrant, appearing during March-June. The tree bears sweetly scented flowers are grown on road side and gardens.

Putranjiva roxburghii (Child Life Tree) is an evergreen ornamental tree, native of tropical Asia and is distributed throughout the greater part of India. Flowers small, axillary, single or in small clusters, yellow in colour, arising in the summer months. The tree is mainly used as an avenue tree because of the dense evergreen foliage on nearly pendulous branches.

Saraca indica (Asoka tree) is a medium sized evergreen tree, reaching to height of 8-10 m. having an erect trunk covered with smooth dark brown bark; branches are spreading. Flowers yellow or orange when first open in February, gradually turn vermillion. They arise in numerous clusters of various sizes, mainly from older branches and some from the trunk. The tree grows well in partial shade and porous soil.

Sarac thapingensis : Normally the tree does not grow more than 8 m high. Yellow flowers arise in large clusters, axillary and terminal during December to March on order shoots and trunks.

Schleichera oleosa (Lac Tree) are large deciduous tree up to 20m high with dense and shady crown. Small yellowish-green flowers appear in short dense axillary clusters in February-March. Flowers are either male or hermaphrodiate.

Spathodea campanulata (Tulip tree, Scarlet bell tree) is a tall and erect handsome evergreen tree reaching a height up to 20m. Large colourful flowers appear in terminal clusters in early February at the end of the branches.

Sterculia villosa is a moderate sized deciduous tree, 12-15 m high. Flower small, membranous, male and hermaphrodite on pendulous panicles on leafless tress. The trees bears numerous clusters of flowers at the end of the shoots in February –March. This quick growing plant should be used in green belts and parks.

Swietenia mahogany (Spanish mahogany): The crown is heavy darkgreen and dense; bark dark grey and ridged. Flowers small, greenish yellow, 0.6 cm across in axillary or sub-terminal panicles.

Taebebuia rosea is large tree of graceful appearances, reaches a height of about 20-25 m. In late-February numerous funnel shaped rosy purple flowers areise in axillary clusters on leafless branches. Flower yellowish inside, 5 lobed, curved about 4 cm across.

Terminalia arjuna (White murdah) is a large deciduous tree with horizontally spreadingbranches. Flowers on erect terminal panicles are born in profusion in April-May. The tree is commonly planted on road side in the northern part of the country.

Thevetia perviaa (Yellow oleander) is small tree, native of west Indies, is widely grown in India. Flowers large, bright yellow, white or pinkish funnel shaped about 5 cm long borne in small clusters during the summer and rains.

Gardens have for long been important in India for three considerations, aesthetic, economic and social.

India is endowed with natural wealth of plant materials of beautiful plant species like those of orchids, rhodoendrons, primula, comelliaetc. Are fund wild in the Himalayan and other mountaneous regions, the Kashmir valley and the famous valley of flowers are also rich sources of indigenous flowers. A large number of these native Indian species have been extensively used for improvement of various flowers in other countries. Some of the Indian flora have been completed and described these basic genetic materials need to be preserved and effectively utilized in the improvement of floriculture in India.

Economic aspects of ornamental horticulture are as important as the aesthetic ones, the floricultural products of commercial importance mainly consist of cut flowers and ornamental foliage plants the word trade in flowers is estimated to be around 13 billion in 1981. Developed countries account for more than 90 percent of the total world in floricultural products. The majority of imports is taken by the European countries in the recent times. The major exporting countries have been the developing ones.

Floriculture is a branch of horticulture which as a very important bearing upon the lives of all human being. The flowers have always played significant role in human society. The ancients used them extensively as symbols of joy and sorrow. Floral offerings to God is an important ritual in every religion. In fact, the evolution and cultivation of ornamental trees are intimately associated with temples and monastries. Hindu scriptures are full of praises for flowers.

Some ornamental trees have become famous in the world because of their peculiar characters. The plants of sequois, Victoria and Rafflesia are famous because of their largest life span, leaf and flower respectively. Some plants are famous because of medicinal use viz. Chincona and Papaver. Some of the beautiful flowers viz. Cacti and Orchids and others because of their immense use in daily life.

Besides these, the flowers also have a therapeutic value, well known to the institutions which care for those who are mentally affected. Similarly, a human being who can admire beautiful flowers ceases to be materialistic and his mind rises to higher plane.

Like all other crops, ornamental plants are also susceptible to many diseases particularly those caused by fungi, bacteria, virues etc. The diseases which ravage all parts of plants are innumerable, the fungal diseases are controllable to a great extent if their symptoms are correctly recognized.

Home gardeners are apt to think of all diseases as caused by parasites and pests. As a matter of fact, may common diseases result from abnormal environment or from poor cultural practices. Chlorosis (lack of green color) may be due to the absence of iron or of magnesium sunlight and heat. Wilting may be due to an excessive sunlight and heat. Wilting may be due an insufficiency of available water in the soil. The home gardener is sometimes discouraged by the multitude of fungi and insect and other pests that destroy the fruits of his labour.

The problems of diseases control have agitated the mind of plant pathologist for many years but no comprehensive work has been done on

fungi causing damages to ornamental plants. In the past many workers including Dey (1946), Sharma (1973, 1975) Sridhar and Krishnaih (1975) Ghodaj Kar et al (1976), Deshpande et al (1977), Khanna and Chandra (1977), Srivastava and Sinha (1978), Vijaya et al. (1978), Lal and Arya (1981), Narain and Singh (1981, 1982), Srivastava et al (1981), Chase (1982), Lal et al (1982) Misko (1982), Perce and McCain (1983) have investigated diseases of some ornamental plants caused by fungi.

Temperature is one of the most important factors which influence biological systems and has a great influence on the metabolism of the micro-organism. Review on effect of temperature on fungal growth have been prepared by Togashi (1949), Hawker (1950), Cochrane (1958) and Deverall (1965). In the present influence of temperature on growth and sporulation of three *Fusarium* spp. have been observed.

The pH effects disease development through its effect on the pathogen or the hose. Suitability of the pH of the medium, is therefore, of a considerable importance for proper growth and sporulation of fungi. In the present investigation an attempt has been made to study the effect of pH on the growth and sporulation of the organisms under study.

Nutritional factors markedly influence growth of micro-organisms. Living organism require about 40 elements for their successful and normal growth. Therefore, it becomes essential to investigate the nutritional requirements of an organism. Fungi like higher plants, need carbon, nitrogen, hydrogen, oxygen, phosphorus, sulphur, potassium, magnesium,

traces of certain metabolites and growth promoting substances for their growth and reproduction. Among them carbon plays a key role.

Like carbon, nitrogen is also employed both for structural and functional purposes by fungi. Nitrogen nutrition of pathogenic fungi has been well illustrated by Wolf et al., (1950), Lilly and Barnett (1951), Cochrane (1958) and. Of the organic sources of nitrogen, the amino acids have been generally considered to be the most common choice for fungal growth and reproduction. It was, therefore, considered desirable to study the nitrogen metabolism of the fungi under investigation. Carbon and nitrogen levels in the culture medium have been known to influence the growth and sporulation of the fungi. Generally it has been reported that lower C/N ration induced sporulation under laboratory conditions (Hasija 1970). In the present investigation anattempt has been made to study the effect of C/N ratio on growth and sporulation of the organisms under investigation.

Soil is supposed to be a medium as a complex environment wherefungi including other micro-organisms almost compete for their existence.

Soil is a sink for pathogenic and non-pathogenic genera of fungi. The relative abundance of both categories in soil depends on their behaviour against each other and the physico-chemical factors (Issac, 1956; Madakavukaran, 1961). Soil is characterized by its heterogeneous nature due to the presence of different types of organic substrates which form different microhabitats for colonization of fungi (Chesters, 1946, Garrett, 1963), hence the active phase of fungi is often limited to the vicinity of the organic

substrates. Root infecting fungi remain dormant in the non-rhizosphere regions of the host (Snyder et al., 1959; Eastoh, 1967, Papavizas, 1967, Papavizas et al., 1968; Smith, 1970; Powelson, 1970) either freely or on dead organic matter.

Among the various physico-chemical properties of the soil, soil temperature, moisture content, aeration, pH and mechanical properties such as soil texture, pore space, organic content, affect the activity of fungi and other micro-organisms (Warcup, 1951; Shaw, 1952; Luthin, 1957; Russell, 1961; Collis-George, 1962; Dwivedi, 1965; Alexander, 1977.

Based on the range of tolerance to temperature the fungi can be grouped into (1). Thermophilic fungi surviving at or above 40° C (2) mesophilic surviving between 10° C and 40° C and (3) psychrophilic thriving at or below 10°C. Stanely and Nimmo (1979) reported that *Cercospora nicotiana* grew at 10-40°C. Hasija (1970) found *that Alternaria citri* grew at 15-35°C. La Touches (1948) has reported *that Chaetomimum sp.* needed higher temperature (40-50°C) *Rhizoctonia solani* accelerates its growth with rise in temperature upto 30°C (Richards, 1923).

The effect of soil moisture on the ecology of soil fungi has been extensively studied and reviewed (Griffin, 1963, a, b, 1966, 1970, 1972). The population of rhizosphere micro-organism is greater at lower moisture levels that at higher one, while the reverse is in the case of non-rhizosphere soil (Stover, 1953; Griffin, 1963 a). The pathogenic fungi are adversely affected when there is increase in microbial population in soil. It has been reported by Menzies (1970) that the production of propagules by many root

pathogens on the substrate in soil was usually much less in soil in high rainfall than in dry irrigated areas due to growth of saprophytic fungi on plant debris.

Soil water is one of the factors influencing the growth and survival of soil borne pathogens. Soil water in relation to plant disease control to antagonism, microbial growth and other factors that affect pathogens in the soil play an important role (Griffin, 1963 ab, 1969; Rovira, 1965; Cook and Flentje, 1967 Cook and Papendick, 1970).

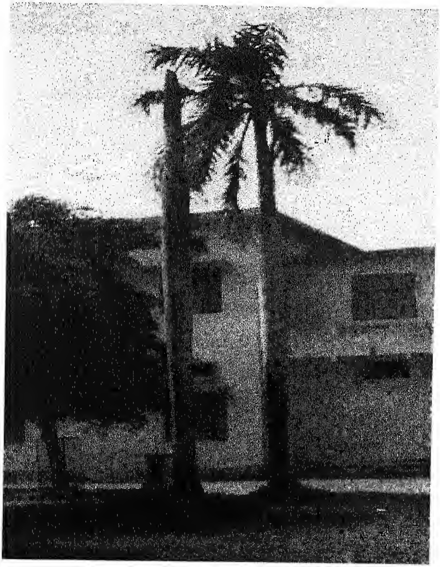
The present problem was undertaken as an integral part of a comprehensive plant of experimental investigation, employing various organized studies for the furtherance of scientific knowledge in this important and complex field of research. The investigation were conducted with recognised methodology.

Since the wilt desease in ornamental plants is matter of great concern their proper management in a cost effective manner has to be fixed out. Thus in the preset work emphasis has been given on following aspects.

Isolations were made from soil as well as wilted plants to identify the responsible pathogens. Three common pathogenic fusaira Vs. *F. oxysporum, F. acuminatum* and *F. semitactum* were selected for the detailed studies. On these pathogens various parameters like effect of environment factors. Pathological survival and control studies have been carried out.

CHAPTER – 2

MATERIALS AND METHODS



Materials and Methods

From 1996 - 2001 the various gardens road sides and public places of Allahabad, Prataphgarh, Fatehpur, Mirzapur, Varanasi and Kanpur and neighbouring districts were regularly surveyed and diseases of ornamental trees viz. *Acacia auriculiformis, Adenanthera paranina, Amberstia nobilis, Azadirachta indica, Bauhinia variegata, Bignonia megapatamica, Cassia fistula, Delonix regia, Eucalyptus citriodora and Saraca indica* etc. which appeared causing extensive damage to their hosts were collected. The characteristic symptoms of the various diseases were carefully studied, the respective causal organism isolated, identified and its pathogenicity established by the usual methods. Potato Dextrose Agar medium (peeled and sliced potato 200g, glucose 20g, agar 20g and distilled water 1000ml) was used for isolating the causal organism by the usual method. After isolation, pure culture of the organism using single culture technique was prepared. The stock cultures were maintained on potato dextrose agar medium. Pathogenicity if each organism with respect to its host was confirmed as Koch's postulates were fully satisfied. Three *Fusarium* species viz., *F. oxysporum schlect, F. semitectum* Barpetey and Ravenel, and *F. acuminatum* Ellis and Everh, were found to cause severe damage to the ornamental trees.

Different Media used in Present Investigation.

1- Potato Sucrose Agar

Potato extract	500 ml
Sucrose	20 g
Agar	20 g
Distilled water	500 ml

The water and potato extract are mixed together and the sucrose and agar added. The mixture is heated slowly until the agar is dissolved and the pH adjusted if necessary to 6.5 with calcium carbonate. It is then dispensed in suitable bottles and autoclaved at 15 psi for 20 min.

2- Potato Dextrose Agar

Potato (scrubbed and diced)	200 g
Dextrose	15 g
Agar	20 g
Distilled Water	1000 ml

New potatoes should be avoided. Boil potatoes for 1 hr. and pass the mixture through a fine sieve, add agar and boil until dissolved, add dextrose and stir-autoclave at 15 psi for 20 min.

3- Oatmeal Agar

Oatemal (powdered)	30 g
Agar	20 g
Distilled water	100 ml

Add oatmeal to water and gradually heat to boiling in a water bath or double saucepan and boil for 1 hr. Strain through muslin and make up liquor to 1 litre with water. Add agar and dissolved. Autoclave at 15 psi for 20 min.

4- Tapwater Agar

Agar	15 g
Tapwater	1000 ml

Sterile wheat straw or rice grains may be added for use as general medium. Many *Fusaria* spore well on this.

5- Nash & Syner's (1962) Pepton PCNB Medium

Difco peptone	15g
Agar	20g
Potassium dihydrogen phosphate (KH_2PO_4)	1 g
Magnesium Sulphate ($MgSO_4$)	1 g
Pentachloronitrobenzene (PCNB 75%	1 g
Wettable powder) 300 ppm streptomycin	
(When cooled)	

6- Papavizas' (1967) Peptone – PCNB modified.

Difco peptone	15g
Agar	20g
Potassium dihydrogen phosphate (KH_2PO_4)	1 g
Magnesium Sulphate ($MgSO_4.7H_2O$)	0.5 g
PCNB – (Terraclor, a commercial product, is 75% active)	
Streptomycin Sulphate	
Chlortetracycline HCL	50 mg
Oxgall	0.5 g

The last two components are thermolabile and should be added to the cooled agar.

7- **Armstrong *Fusarium* medium**

Sucrose or Glucose	20 g
Magnesium Sulphate ($MgSO_4.7H2O$)	0.4 g
Potassium Chloride (KCL)	1.6 g
Potassium dihydrogen phosphate (KH_2PO_4)	0.2 g
Ammonium Nitrate (NH_4NO_3)	0.1 g
Agar	15 g
Distilled water	1000 ml.

8- **Medium used to study staling of *Fusarium oxysporum*** (Park, 1961)

Glucose	0.7 g
Magnesium Sulphate ($MgSO_4.7H2O$)	0.5 g
Potassium dihydrogen phosphate (KH_2PO_4)	0.2 g
Ammonium Nitrate (NH_4NO_3)	0.1 g
Agar	15 g
Distilled Water	1000 ml.

Wheat or rice straw or plant stems in Petri dishes or longer pieces standing in tap water agar or in water in large medical flats or other suitable containers.

These organisms were also isolated from the narsaries of their respective hosts. In the present investigations the above mentioned species of *Fusaria* were selected for detailed study.

In order to study the perennation of the diseases under investigation *Fusaria* present in the soil were also isolated from the garden of Botany Department, University of Allahabad. Chandra Shekhar Azad Park, Allahabad and Agriculture Institute Naini (Now Deemed University),

Allahabad. Random soil samples from the above gardens were collected regularly every month for full one calendar year (Oct 1999- Jan 2000). The method used for collecting soil samples was similar to that used by Saksena and Mehrotra (1952) and Sarabhoy (1963). Soil from various depths (7.5, 15.0, 22.5 and 30.0 cms) were scraped from the four sides of the pit using a sterilized sharp steel blade. The samples collected from various depths of a locality were packed separately in pre - sterilized polythene bags and brought to the laboratory where the samples were air dried, pulverised and passed through a sieve (2mm).

The soil dilution and plate count method were used to determine the number of *Fusarium* Colonies in a particular sample. Modified Czapek - Dox agar medium (Singh and Nene, 1965) containing sodium nitrate ($NaNO_3$) 2.0 g, dipotassium monohydrogen phosphate (K_2HPO_4) 1.0 g, Magnesium sulphate heptahydrate ($Mg(SO_4)_2.7H_2O$) 0.5 g, ferrous sulphate (FeSO4) 0.01g, sucrose ($C_{12}H_{22}O_{11}$) 30 g , agar 20 g and distilled water to make up 1000 ml was used. After autoclaving, fresh solution of malachite green (50mg/1) and Captan (100 mg/1) was added. The medium was left to cool a little and then 20 ml of the medium was poured into each sterile plate and left to solidify. The dilution (1:1000) was added to the petridishes containing the sodium medium. These petridishes were then incubated at 25° ± 1°C for 3 - 5 days.

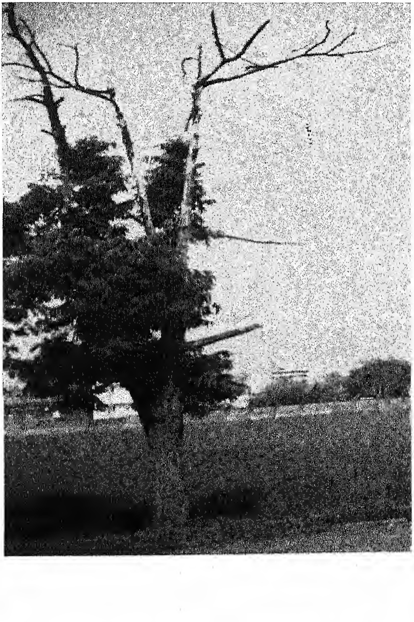
Meteorological data for the concerned year were obtained from the Air Force Meteorological Station, Bamrauli Allahabad. The pH value of the collected soil samples was determined with the help of a pH-meter and the

moisture content by drying a sample of 5 g of soil in an electric oven at 105°C for 12 hrs.

For survival studies, soils of the garden of Chandra Shekhar Azad Park, Allahabad was selected. The soil was dried, sieved and infested with 3% maize meal sand culture. This was prepared in 250 ml conical flasks. Each flask was filled up with sand and maize meal mixture (150 g of dry clean sand + 4.5 g of maize meal) and 20 ml of distilled water was carefully added (100 g dry sand holds 20 ml water at saturation so 20 ml for 150 g sand maize meal mixture gives about 65% saturation) to each flask. There flask were then autoclaved for 30 min at 15 lbs pressure and were inoculated with agar inoculum discs obtained from the margin of a 7 – 10 days old colony of the fungus maintained on potato dextrose agar. Flasks were incubated for about 4 weeks at 25°± 1°C and were shaken after 2 weeks to evenly disperse the fungi. 3% maize meal cultures of *Fusarium* species in these flasks were ready to be used as inoculum for infesting the soils stored in glass jars. 5 g of the inoculum (maize meal sand sulture) was mixed with 100 g of unsterilized air dried soil. In order to evenly distribute the inoculum in the jars filled with the soil, the jars were carefully shaken and the contents adjusted at 54% water holding capacity. Each jar was weighed and its weight noted on the jars. To keep moisture content at 54% the jars were weighed on a pan – balance twice a week and distilled water was added where needed to restore the original weight. The inoculated glass jars were kept in the laboratory covered with petridished halves to reduce moisture loss and

CHAPTER – 3

IS0LATION STUDIES



ISOLATION STUDIES

A comprehensive survey of various gardens, road sides and public places of Allahabad, Pratapgarh, Azamgarh, Mirzapur, Varanasai, Ambedkar Nagar, Mau, Ballia, Ghazipur and its adjacent regions were made and roots of various wilted ornamental trees and soil were collected. Since *Fusaria* are well known wilt causing vascular pathogens therefore main emphasis in its isolation and study have been given on it. Blotter Agar Plate and Botter Roll methods, were used for isolation of *Fusarium* species. *Fusaria* were isolated, purified and maintained on Malt-extract and Potato Dextrose Agar media. Morphological studies were carried out and identifications were made.

Fusaria isolated from soil and wilted ornamental trees at various places are as follows :

TABLE - 1

Fusaria isolated from various garden, soils and roots of wilted trees

Name of Ornamental Trees	***Fusaria isolated from soil***	***Fusaria* isolated from wilted ornamental trees**
Acacia Auriculiformis	*F. oxysporum*	*Fusarium oxysporum*
	F. solani	F. equiseti
	F. equiseti	F. fusarioides
	F. acuminatum	F. species
	F. spp	F. spp.
	F. semitectum.	F. sp.
Amhesstia nobilis	*F. acuminatum*	*F. oxysporum*
	F. oxysporum	F.*acuminatum*
	F. moniliformae	*Fusarium* sp.
	F. solani	*Fusarium* sp
	F. semitectum.	
Azadirachta indica	*F. oxysporum*	*F. semitectum*
	F. equiseti	F. monliformae
	F. solani	*F. oxysporum*
	F. acuminatum	
	F. semitectum.	
Bauhinia vertigata	*F. acuminatum*	F. solani
	F. solani	*F. oxysporum*
	F. semitectum	*F. semitectum*
	F. oxysporum	F. sp.
Bignonia mega potanica	*F. oxysporum*	*F. oxysporum*
	F. equiseti	F. moniliformae
	F. acuminatum	F. *acuminatum*
	F. solani	F. equiseti
	F. semitectum	F. sp.
Callistemon lamerolatus	*F. acuminatum*	*F. niveble*
	F. oxysporum	*F. sumbaein*
	F. moniliformae	*F. garminearum*
	F. cumorum	*F. sp.*
	F. semitectum	*F. sp.*
	F. sp.	

Calophyllum inophyllum	*F. leterosporum*	*F. oxysporum*
	F. species	F. solani
	F. equiseti	F. sp.
	F. sp.	F. sp.
	F. solani	F. sp.
	F. oxysporum	
	F. smitectum	
	F. acuminatum	
Cassia Fistula	*F. solani*	*F. oxysporum*
	F. heterosporum	F. roseum
	F. oxysporum	F. sp
	F. smitectum	F. sp
	F. acuminatum	
	F. sp.	
	F. sp.	
Cassia maginata	*F. solani*	F. acurinatum
	F. oxysporum	F. sp.
	F. smitectum	F. sp.
	F. acuminatum	F. oxysporum
	F. stipaldes	F. sp
	F. culmorum	
	F. sp	
Cochlospermum gossypium	*F. oxysporum*	F. lateritium
	F. smitectum	F. anthrosporiosdes
	F. acuminatum	F. stil bodies
	F. solani	F. sp.
	F. roseum	F. sp.
	F. graminearum	
	F. poae	
Crataeva roxburghi	*F. solani*	F. oxysporum
	F. juruanum	F. moniliforms
	F. oxysporum	F. sp
	F. smitectum	F. sp
	F. acuminatum	F. sp

	F. sp	
	F. sp	
Delonix regio	*F. oxysporum*	F. larvarum
	F. smitectum	F. solani
	F. acuminatum	F. sp
	F. moniliform	F. semitectum
	F. solani	
Erythrina indica	*F. oxysporum*	F. fusaicide
	F. smitectum	*F. oxysporum*
	F. acuminatum	F. sphareal
	F. solani	
	F. sp	
	F. sp	
Eucalyptus citriodora	*F. oxysporum*	F. boxieola
	F. moniliform	F. eoncalas
	F. rasum	F. sp
	F. acuminatum	F. sp
	F. smitectum	
	F. solani	
Eucalyptua Globulus	*F. solani*	F. xylarioides
	F. fusiroidr	F. *acuminatum*
	F. oxysporum	F. oxysporum
	F. smitectum	F. solani
	F. acuminatum	
	F. sp	
	F. sp	
Ficus clastica	*F. stilboides*	*F. sulphuraum*
	F. gaminearum	*F. sambucinum*
	F. solani	*F. oxygpon*
	F. equisiti	*F. sp.*
	F. oxysporum	
	F. semitectum	
	F. acuminatum	

Ficus religiosa	*F. nivale*	*F. oxyporum*
	F. sumbacin	*F. heterosporum*
	F. solani	*F. spp.*
	F. oxysporum	*F. spp.*
	F. sp.	*F. spp.*
	F. smitectum	
	F. acuminatum	
Gardenia latifalia	*F. stilboides*	*F. literitium*
	F. eulmorum	*F. oxysporum*
	F. auenaeouno	*F. rasum*
	F. saloni	*F. spp.*
	F. equiseti	*F. sp.*
	F. oxysporum	
	F. smitectum	
	F. acuminatum	
Hibiscus populneus	*F. saloni*	*F. epistromum*
	F. roscum	*F. solani*
	F. moniliformas	*F. gigas*
	F. poae	*F. oxysporum*
	F. sp.	*F. spp.*
	F. oxysporum	
	F. smitectum	
	F. acuminatum	
Magnolia grandiflora	*F. fusiroides*	*F. oxysporum*
	F. heterosporum	*F. rascum*
	F. gigas	*F. equisti*
	F. solan	*F. spp.*
	F. sp.	
	F. oxysporum	
	F. smitectum	
	F. acuminatum	

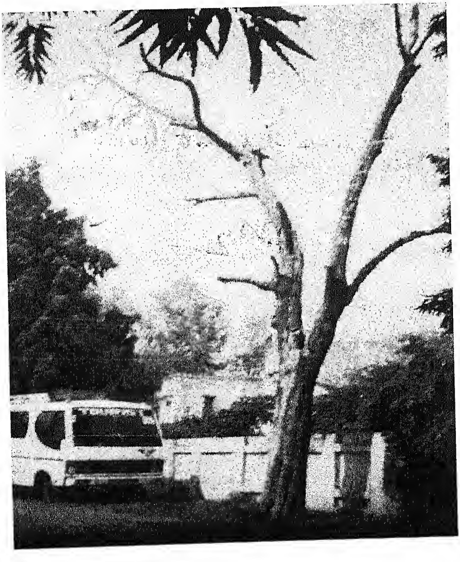
Michelia champaca	*F. oxysporum*	*F. solani*
	F. equiseti	*F. moniliformal*
	F. solani	*F. sp.*
	F. spp.	*F. sp.*
	F. smitectum	
	F. acuminatum	
Polyalthia langifolia	*F. solani*	*F. moniliforma*
	F. oxysporum	*F. nivale*
	F. xylatioides	*F. sp.*
	F. sp.	*F. sp.*
	F. sp.	
	F. smitectum	
	F. acuminatum	
Putranjia roxburghii	*F. heterosporum*	*F. oxysproum*
	F. solani	*F. moniliformar*
	F. poal	*F. acuminatum*
	F. larvarum	*F. sp.*
	F. sp.	*F. sp.*
	F. sp.	
	F. oxysporum	
	F. smitectum	
	F. acuminatum	
Saraca indica	*F. solani*	*F. opxysporum*
	F. oxysporum	*F. moniliforme*
	F. roscum	*F. semitectum*
	F. equistal	*F. sp.*
	F. spp.	
	F. smitectum	
	F. acuminatum	

Terminalia arjuna	*F. semitectum* *F. saloni* *F. acuminatum* *F. spp.* *F. oxysporum* *F. smitectum* *F. acuminatum*	*F. acuminatum* *F. heterosporum* *F. spp.* *F. spp.*
Theuctia preuvisana	*F. saloni* *F. oxysporum* *F. roscum* *F. eonealar* *F. xylarioides* *F. sp.* *F. sp.* *F. species* *F. smitectum* *F. acuminatum*	*F. equisiti* *F. acuminatum* *F. moniliformed* *F. oxysporum* *F. specis* *F. species* *F. species* *F. species*

Isolation studies revealed that out of 34 speics of Fusarium 30 speics from soil sample and 23 speics from or namental wilted trees were isolated.

CHAPTER – 4

PATHOLOGICAL STUDIES



PATHOLOGICAL STUDIES

In *Fusarial* wilt disease, plants suffer from dehydration and show symptoms of drought. Epinasty of leaves, petioles and branches, vein clearing and chlorosis of leaves followed by browning and defoliation, vascular browning; formation of gums and gels are the most common symptoms of the wilt. The petioles bend downwards, forming an obtuse angle with the main stem. Browning of vascular elements, is another pronounced symptoms of *Fusaria*l wilt.

The genus *Fusarium* is a very successful soil inhabitant and once established, persists for several years. Snyder and Hansen have grouped all vascular wilt *Fusaria* into one species, viz *F. oxysporum* comprising several forms are specials.

In most of the cases, the disease starts with yellowing and drying of upper (terminal) leaves in the outer shoots of a plant. Symptoms start to appear after 15 – 35 days of rains. The drying of leaves progresses downwards and very rapidly up to the junction of the branch. Sometimes all the leaves of a single branch show epinasty the [etioles bend downwards, forming and obtuse angle with the main stem. The wilted leaves become dry and brittle.

The three species of *Fusarium* viz. *F. oxysporum F. semitectum* and F. *acuminatum* which commonly occur in soils of different gardens around Allahabad and they were also isolated from wilted ornamental trees were

also taken for pathological studies. These studies were carried out form the same stock culture and hence the methods used for isolating, subculturing etc., were similar to those described earlier. For pathogenicity tests Madina, Palm, Polyaethier, Pipal, Bottal brush, Mattas, Eucalyptus, Dalbergia, Kaner and Thuja. Seedlings of same size and age (6 month old) were taken. Pahogenicity tests were carried out by the following methods.

1- The seedlings root both uninjured and injured (10 injuries by sterilized needle per root) were dipped in spore suspension (about 100 spores per lower field of compound microscope) of *Fusarium* species. The seedling were replanted in plastic pots. Controls were simultaneously maintained.

2- The seeding were kept in culture tubes containing 20 days old culture filtrates of *Fusarium* species. In case of control, seedlings were kept in sterilized distilled water. Daily observation were made.

Reisolations were always made in order to confirm the infection with particular *Fusarium* species. Ten seedlings per treatment were taken in each case. The results of both set of experiments are summarized in the table 2.

Results from the above pathogenicity test (first set) clearly show that all the three species of *Fusarium* were capable of causing wilt of Madina, Palm, Polyalthia, Pipal, Boattal brush, Amaltas, Eucalyptus, Dalbergia,. Kaner and Thuja seedlings. The wilting was characterized by gradual withering, yellowing and drying of leaves. Later on, it was followed by drying of entire seedlings. It was observed that there was slightly higher

percentage of infection in case of injured root seedlings than those uninjured. Out of the three species of *F. oxysporum* was more pathogenic to Madina, Palm, Polyalthia, Pipal, Boattal brush, Amaltas, Eucalyptus, Dalbergia,. Kaner and Thuja seedlings than the other two species, as it caused a higher percentage of wilting in the seedlings.

Results from another set, where the seedlings were kept in culture filtrates of *Fusarium* species, showed that seedling wilted within seven days. All the seedlings kept in culture filtrates of *F. oxysporum* and *F. semitectum* wilted while in F. *acuminatum* the percentage was a little less. Controls remained healthy in both set of experiments. Thus from the above experiments it is clearly evident, that *F. oxysporum* and *F. semitectum* causes more damage than other one species of *Fusarium* and from seconf set that some toxic substance also plays a role in causing wilting of Madina, Palm, Polyalthia, Pipal, Boattal brush, Amaltas, Eucalyptus, Dalbergia,. Kaner and Thuja seedlings. An attempt was therefore made to detect the toxic substances (Fusaric acid) in the culture filtrates of the three species of *Fusarium*.

Fusaric acid was originally isolated from *Fusarium* heterosporum by Yabuta et al, (1934) and shown to be butyl picolinic acid. It is a non – specific vivotoxin. Its production in vitro by a number of fungi, all belonging to family Hypocreaceae has been demonstrated by (Gaumann (1957), *Fusarium* oxyosporum, (f. lycopersici, f. vasinfectum, f. niveum, f. batates, f. nicotianae) (Gaumann et al,1952), F. solani, F. monoiliforme, F. majus (Lakshminarayan and Subramanian, 1955) and *Nectria cinnabarina* (Nishimura, 1957).

Much work has been by a number of workers including Chandramohan and Mahadevan (1968), Kuo and Scheffer (1964) and Sandhu (1960) about the importance of Fusaric acid related to wilt symptoms.

Fusarium species were grown for 20 days in 100 ml of Czapek's liquid medium in 500 ml. Erlermeyer flasks. The culture filtrates were collected and centrifuged at 2000 rmp fro 20 min. The clear supernant was taken and the pH was adjusted to 4.0 by adding 2 NHCl 100 ml. Of the filtrate was mixed with equal volumes of ethyl acetate at least 4 times in a separating funnel allowing 15 min for each dryness. 1 to 2 ml. Of ethanol was added to dissolve the residue. Drops of known volume (0.005 ml.) of filtrates as well as an index solution of fusaric acid were kept on Whatman's filter paper No. 1 spotted chromatogram were run ascendingly for 10 – 12 hrs.. in butanol, formic acid and water (75:15:10). Chromatograms were dried and sprayed by bromophenol blue (0.04% in 90% ethyl alcohal).

Fusaric acid was detected in al the present species of *Fusarium*. The amount produced by them, however, varied on the basis of visual comparison of the chromatograms, based on the fact that the size and coloue intensity of the spots, the three species of *Fusarium* are graded as follows :

F. semitectum	....	+++++++
F. oxysporum	....	++++++++
F. *acuminatum*	....	+++

MORPHOLOGY OF FUSARIA

1- Fusarium semitectum, Berk & Rav.

Whitish or light orange white, compact mycelial growth covering the whole seed was seen alongwith the characteristic whitish, shiny, highly branced conidiophores bearing easily recognizable macroconidia giving an appearance of flower. Branced conidiophores with macroconidia easily be observed on the periphery of colonies.

Colonies on PDA whitish increnate or isaballin with abundant aerial mycelium of whitish cottony growth in the early stages and later changed into the light yellow or buff brown; Mycelium septate, 3.0 – 6.0 µ thick, brand creeping; Conidiophores arise singly or in groups, whitish, shiny, highly branched bearing macroconidua; Macroconidia developed on aerial mycelium as fusoid, hyaline, 0 to 5 septate but occasionally up to 7 septate, wedgeshaped, measured on the basis of septation.

Microconidia not observed

Chlamydospores not observed

2- *F. acuminatum* Ellis and Everh

Culture On PDA the mycelium varies from white to brownish red, and frequently but not always produce a deep red or carmine red colour in contact with agar. Sporodochia are red to salmon coloured.

Microconidia Develop in aerial mycelium from simple phialides, measuring 12 – 16 x 3 – 4 in size.

Macroconidia Broadly falcate, strongly dorsiventral 3 – 5 septate, measuring 30 – 55 x 4.0 – 4.8 in size.

Chlamydospores Intercalary, thick walled globose to oval measuring 10 – 15 x 15 – 18.

Booth (1971) has, however described this species with 3 – 7 septate macroconidia.

3- *Fusarium oxysporum* Schlecht.

Culture On PDA the fungus produced a violet pigment in contact with agar. Sclerotia are usually blue – black. Sporodochia are cream to salmon coloured.

Microconidia Borne on simple phialides, generally abundant, variable, ellipaoid, cylindrical straight to curved, 5 – 12 x 2.2 – 3.5μ in size.

Macroconidia Thin walled, generally 3 – 4 septate, fusoid – subulate and pointed at both ends, 25 – 45 x 3.0 – 4.5μ in size.

Chlamydospores Smooth walled, abundant, both terminal and intercalary, generally solitary but occasionally formed in pairs or in chains, they are 5.5 – 8.0 x 5 – 7μ in size.

TABLE -2

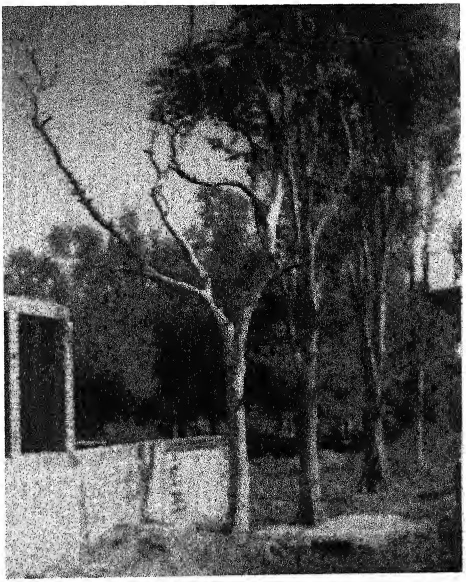
Pathogenicity test and percentage wilting of some ornamental trees at seedling stage.

Seedling (ornamental trees)	Organism	Percentage of seedling wilted		
		After 1 week		After 4 days in culture filtrate
		Uninjured	Injured	
Madina	*F. oxysporum*	40	50	60
	F. semitectum	50	60	90
	F. *acuminatum*	25	35	50
	Control	Nil	Nil	Nil
Ficus religiosa	*F. oxysporum*	42	52	61
	F. semitectum	55	59	90
	F. *acuminatum*	31	41	51
	Control	Nil	Nil	Nil
Thuja compacta	*F. oxysporum*	40	50	50
	F. semitectum	48	58	85
	F. *acuminatum*	30	45	48
	Control	Nil	Nil	Nil
Calistimam lesnsiolatus	*F. oxysporum*	40	50	60
	F. semitectum	50	60	95
	F. *acuminatum*	30	20	50
	Control	Nil	Nil	Nil
Palm spp.	*F. oxysporum*	43	55	52
	F. semitectum	54	65	98
	F. *acuminatum*	36	45	52
	Control	Nil	Nil	Nil
Cassia fistula	*F. oxysporum*	45	58	60
	F. semitectum	50	62	95
	F. *acuminatum*	35	48	68
	Control	Nil	Nil	Nil
Thivetia oderatum	*F. oxysporum*	50	60	90
	F. semitectum	34	42	52
	F. *acuminatum*	15	20	35
	Control	Nil	Nil	Nil

Eucalyptus spp.	*F. oxysporum*	45	55	65
	F. semitectum	55	65	95
	F. *acuminatum*	42	52	61
	Control	Nil	Nil	Nil
Polyalthia spp.	*F. oxysporum*	48	58	60
	F. semitectum	50	65	90
	F. *acuminatum*	45	56	65
	Control	Nil	Nil	Nil
Dalbergia sissoo	*F. oxysporum*	50	65	72
	F. semitectum	52	68	90
	F. *acuminatum*	45	58	65
	Control	Nil	Nil	Nil

CHAPTER – 5

ENVIRONMENTAL STUDIES



Environmental Studies

Environment plays an important role in the annual recurrence of soil-borne pathogens. Adverse environment can limit the annual recurrence of a pathogen and reduce the density and potency of the inoculum. The study of pathogen in relation to environment can solve the problem of soil-borne diseases. Bateman (1963) studies factorial analysis of environment and pathogens in relation to development of poinsettia root-rot comples. According to Trujillo and Synder (1963), Games and Domesh (1969) and Singh and Bhargava (1982) the distribution of fungi in soil studied by them was affected by envrionment. Khati et al. (1982) recorded annual recurrence of three fungi viz., *Macrophomina phaseolina, Rhizoctonia solani* and *Sclerotium rolfsii* in cultivated fields of Allahabad.

The environment is an everchanging factor. The complex of factors which affect diseases development are temperature, humidity, light, atmospheric pressure, wind, rain, dew and soil.

Ward, (1880), emphasized the role of environment in the epidemiology of coffee rust, Jones, (1920); affirmed that "the role of environment to the predisposition of host as well as to the virulence of the parasite, can not be overemphasized."

Temperature, humidity and other aspects of the physcio-chemical conditions of the soil, the edaphic factors, particularly soil reaction, soil type and soil fertility are important environmental factors. In the period prior to infection these factors exercise influence on the predisposition of the host

and the preparedness of the pathogen. If the environment favourable for the pathogen is the same, as for the pathogen. This dissimilarity in suitabilities of environments for hosts and pathogen can be exploited for diseases control.

Foster and Walker, (1947), investigated the influence of soil conditions on the predisposition of tomoto plants to *Fusarium* wilt. Spore germination of Ustilago avenae and severity of the disease are at their maximum when the water content is 30 per cent of the water holding capacity of the soil, severity being lower at 60 per cent and lowest at 80 per cent Bartholomew and Jones, (1923), Jones, (1923). Excessive soil mositure may lead to lack of oxygen, thus hampering spore germination Jones, (1923).

Vascular wilt pathogens are mostly soil borne and colonise in the non-living xylen vessels. Their propagules and metabolites are transported up in the transpiration stream. The genus *Fusarium* is a very successful soil inhabitant and once established, persisits for several years. Wollenweber and Peinbonz, (1935); and Snyder and Hansen, (1940); have grouped all vascular wilt *Fusaria* into one species viz. *Fusarium oxysporum*.

According to Menzies, (1963); "By far the most common non-host environment for organisms in the soil, which, indeed, is the final resting place for all terrestrial life. Therefore, the capabilities possessed by plant disease organisms for surviving in a soil environment are of great importance to plant pathology" He wrote further that plant pathogens, after

parasitizing the host plant, may enter the soil in or on host tissue or free in the form of propagative or resting structures.

Low soil temperature and moisture and slightly acid soil during the pre-emergence period are favourable for infection of *Sphacelotheca sorghi* Kulkarni, (1922); Reed and Fairs, (1924); found that severity of disesase decreased generally with increasing soil moisture. Ling, (1941); established, by comparing soil moisture after seedling emergence, that the development of stalk smut of rye *Urocystis occulta* after the initial infection of the pre-emergence seedling is favoured by dry soil. Rabein, (1927); found that Tilletia caries may be established over a great range of soil moisture during the germination of wheat grain.

Shen, (1940); reported prolific development of *Fusarium culmorum* in wheat seedling in dry soil with 30 percent water holding capacity but at 50 and 80 percent water-holding capacity the disease was less servere. Colhoun et al, (1968) obtained similar results. Soil type may be important to development of seed-borne infections. Walker and Snyder, (1942); have demonstrated that *Fusarium* wilt of pea becomes established more rapidly in some soils than in others. Low, waterlogged, acid soils often favour development of soil and seed-borne fungi, Stapel and Bovien, (1943).

Diseases incidence of *Fusarium nivale* in wheat was reduced at 4 different temperaturs with increase in soil mostiure, Miller and Colhoun, (1969).

The optimum soil temperature for development of *Fusarium* wilt of tomato, *F. oxysporum, f. lycopersici* is 27° C Clayton, (1923) for *Fusarium*

wilt of cotton *F. oxysporum F. vasinfectum* is 28-32°C Muskett and Colhoun, (1947); Lehman, (1943); found that 13°C seedling from soyabean seed encrusted in oospores of *Peronospora manshurica* were infected systematically at a rate of 40 percent whereas no infection occured at 18°C or above. In many diseases where infection of seeds or seedlings affects severity of infection. The speed of germination and emergence depends on soil temperature and moisture. These conditions can be modified by altering the date of sowing.

Alongwith soil environment, atmospheric environment was also important. Temperature, humidity and rainfall affected the annual reccurence of pathogen in soil. A very high summer temperature and a very low winter temperature reduced the activity of pathogen in soil. Like temperature high rainfall and moisture reduced the amount of pathogen in soil by reducing their oxygen supply.

The present chapter deals with the study of annual recurrence of *Fusaria* in different soils with respect to environmental factors. The environmental factors included moisture, pH, percentage carbon and nitrogen of the soil as well as atmospheric temperature, humidity and rainfall.

The result presented in Table 3 show much variation in the *Fusarium* population round the year though the trend of variation is simialr in the soils of the three different areas. In all cases, the maximum number of colonies are observed during October.

A gradual decrease in the number of *Fusarium* colonies is seen during March to June, minimum number being recorded in June. The population of *Fusaria* increases a little in July. The population of *Fusaria* in all the different soil samples increases rapidly from August to October and gradually decreases from November to January. Similar result were obtained by Singh and Bhargava, (1982) from some *Fusaria*, Khati et al. (1982) observed maximum population of the three fungi studied by them in dry months (cold/ warm) when organic carbon and nitrogen of the soils was high.

In the present investigation the variation in the number of *Fusarium* colonies appear to be controlled by enviromental conditions as well as soil conditions such as percentage of carbon, nitrogen, mositure and pH of the soil.

It appears that the micro-climate of the soil plays a significant role in the propagation of fungal disease generation after generation, thus much emphasis should be given in the treatment of the soil on which nursery activities and pit filling soil used in the new areas where ornamental plants to be grown. For successful propagation of different valuable ornamental plants the suggested methods and approach is required to be adopted to eliminate the disease incidence in the future.

Table -

Distribution of Fusarium Colonies is soils having different ornamental trees from three fields.

Months	Fields	Crop	Soil pH	Moisture (%)	N_2 (%).	Organic carbon (%)	Organic Matter (%)	Atmospheric Temperature		Relative Humidity		Total Rain Fall (mm)	*Fusarium* colonies per 50 mg Soil
								Min	Max	Min	Max		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
October 1997	A	Madina	7.5	18.1	1.34	1.01	1.60	14.8	35.6	25	79	2.3	41
	B	Palm Spp.	7.5	24.4	1.00	1.03	1.80						48
	C	Polyalthia Spp.	7.4	25.2	1.18	1.19	2.10						36
January 1998	A	Madina	7.6	1.9	1.34	0.69	1.21	3.6	26.2	29	72	0.1	28
	B	Palm Spp.	7.9	13.7	1.01	1.21	1.19						35
	C	Polyalthia Spp.	7.7	7.8	1.18	1.19	1.30						34
April	A	Madina	7.5	7.7	1.22	0.82	1.41	13.6	43.2	6	19	Trace	26
	B	Palm Spp.	7.9	9.8	0.95	0.79	1.33						31
	C	Polyalthia Spp.	7.5	9.6	1.02	0.94	1.70						22
July	A	Madina	8.0	22.4	1.10	0.91	1.50	23.8	38.8	54	95	342.6	8
	B	Palm Spp.	7.88	31.4	0.89	0.84	1.41						13
	C	Polyalthia Spp.	7.8	26.4	1.07	0.94	1.71						12
October	A	Pipal	6.8	12.8	1.46	0.68	1.17	15.0	35.0	32	78	5.8	39

	B	Bottlebrush	7.2	15.8	1.14	0.61	1.03						49
	C	Amaltas	6.9	18.3	1.41	0.64	0.04						30
	A	Pipal	6.9	17.9	1.48	1.59	2.68						26
January	B	Bottlebrush	7.5	22.2	1.01	1.19	2.11	2.3	31.2	32	100	00.00	38
	C	Amaltas	7.3	23.4	1.30	1.79	2.89						31
	A	Pipal	6.9	16.8	1.20	1.00	1.56						20
April	B	Bottlebrush	7.6	23.1	0.96	0.990	1.39	10.0	45.2	7	42	9.6	33
	C	Amaltas	7.2	225.0	1.35	1.35	1.38						25
	A	Pipal	7.7	5.7	1.54	0.69	1.25						6
July	B	Bottlebrush	7.8	12.28	1.12	0.62	1.10	23.6	36.2	56	100	255.3	14
	C	Amaltas	7.6	6.8	1.42	0.61	1.07						10
	A	Eucalyptus	7.7	3.7	1.42	0.71	1.28						37
October	B	Dalbergia Spp.	7.8	12.7	1.04	0.70	1.20	15.0	36.4	30	88	12.6	45
	C	Kaner	7.7	6.9	1.37	0.68	1.10						32
	A	Eucalyptus	7.7	12.30	1.46	0.58	0.96						25
January	B	Dalbergia Spp.	8.0	14.48	1.14	0.54	0.94	5.3	26.6	31	70	11.7	33
2000	C	Kaner	7.6	11.78	1.37	0.63	1.07						30

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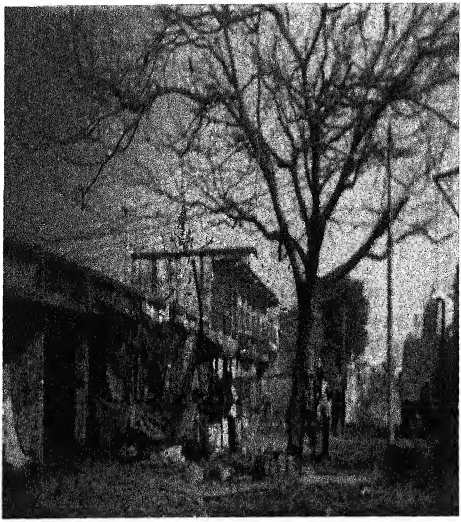
CHAPTER – 6

SURVIVAL STUDIES



SURVIVAL STUDIES

EFFECT OF TEMPERATURE

The study of temperature gives an insight about the environmental conditions suitable for survival and propagation of a pathogen in nature. Like all living organism fungi also require an optimum temperature for best growth and development. Most fungi are able to grow at temperature ranging from 5°C to 35°C the optimum being 25°C to 30°C. Usually, fungi do not grow below 0°C or about 40°C, but exceptions are not infrequent. In a number of cases it has been observed that fungi are more resistant to lower temperatures than to higher temperatures because at lower temperature their living activity ceases, while at higher temperatures they are killed or destroyed. Pabasenko (1967), stated that "as a rule fungi are more tolerant to lower than to higher temperature since the latter coagulates cell proteins".

Various investigators including Rogers (1939), Bega and Smita (1962), Munnecke and Morre (1969), Bente and Kabana (1981), Minogue and Fry (1981), Khati et at. (1983) have investigated the effect of temperature on the growth and survival of a number of fungi. Leach (1947) studied the effect of temperature on damping – off diseases of various seedling host species by a number of different fungal pathogens.

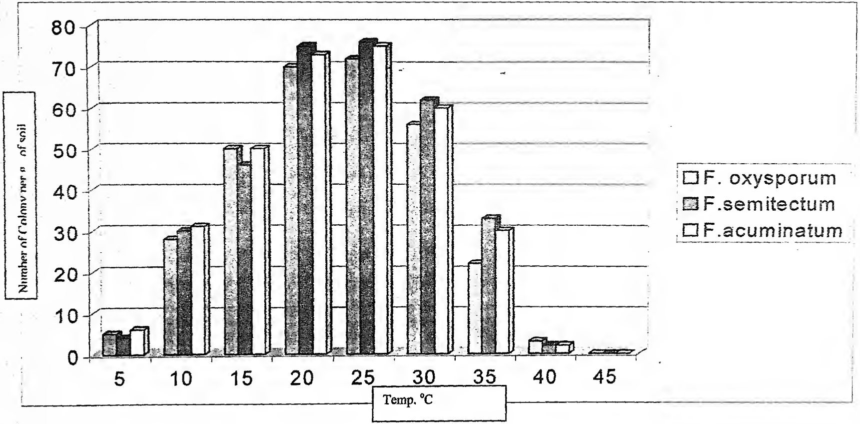
In the present investigations an attempt has been made to determine the cardinal and the optimum temperatures for the survival in soil of the isolates under study. With this in view the survival of *Fusarium* species at the under mentioned temperatures was studies : 5O°C, 10°C, 15°C, 20°C, 25°C, 30°C, 35°C and 40°C. The results have been summarized in Table 3.

TABLE - 3

Effect of temperature on the survival of *Fusarium* species.

	Number of colonies per 50 mg. of soil		
Temperature (°C)	***F. oxysporum***	***F. semitectum***	***F. acuminatum***
05	05	04	06
10	28	30	01
15	20	46	00
20	70	75	73
25	72	76	75
00	06	62	60
35	22	33	30
40	03	02	02

Effect of temperature on the survival of *Fusarium species* :



From the table, it is seen that the maximum survival of all the *Fusarium* species is observed between 25°C and 30°C, any increase or decrease in this temperature results in a decrease in the number of colonies produced. At 25°C maximum number of colonies of *F. acuminatum F. oxysporum* were obtained. In case of *F. semitectum*, however, maximum number of colonies were observed at 25°C. at 5°C and 40°C the survival of the fungi under investigation was minimum, while at 45°C no colonies developed. Similar results were also obtained by Gondo (1962) for Corticum rolfsii. Singh and Bhargava (1981) observed maximum survival of *Fusarium* species at soil temperature ranging between 20°C and 25°C.

EFFECT OF MOISTURE

The impact of soil moisture on the survival of fungi is well known. Different types of soil differ in their water holding capacity. Most fungi require an optimum moisture for germination of their spores, vegetative development and sporulation. Variation in soil moisture within the range that allow growth of plants probably has little direct effect on the survival of pathogens, although it may profoundly influence the incidence of diseases. Root infection becomes more severe with increasing amount of water and maximum infection occurs at saturation point. Moisture determines concentration of oxygen in soil and this affects accumulate in toxic concentrations and thus root becomes prone to infection.

Soil fungi causing wilt are governed by high moisture, wet soil even to the saturation point. According to Beach (1947), the severity of damping – off caused by *Rhizoctonia solani* increased with increasing moisture up to 65% of saturation and then decreased abruptly. Flooded soil undergo physical, chemical and biological transformation that greatly alters their microbial population and results in deficiency pf oxygen which is much needed by plant pathogens for its growth and survival.

Various investigators particularly Rogers (1939), Blair (1943), Papavizas and Davey (1961), Menzies (1962), Sen Gupta and Roy (1971), Dhingra and Sinclair (1975), Singh and Bhargava (1981), Emberger and Welty (1983), Khati et al. (1983), have studied the effect of soil moisture on the saprophytic survival of a number of fungi.

Flood fallowing is relevant to practice and is used as a control for many soil – borne diseases. Moore (1949) observed flooding as a means of destroying the sclerotia of *Sclerotinia sclerotiorum*, reported control of *Verticillium dahliae* by soil flooding. Therefore, in the present investigations survival in soil of all the *Fusarium* species have been studied at different percentage of water holding capacity ranging from 10 to 100%. Rsult obtained are presented in Table 4.

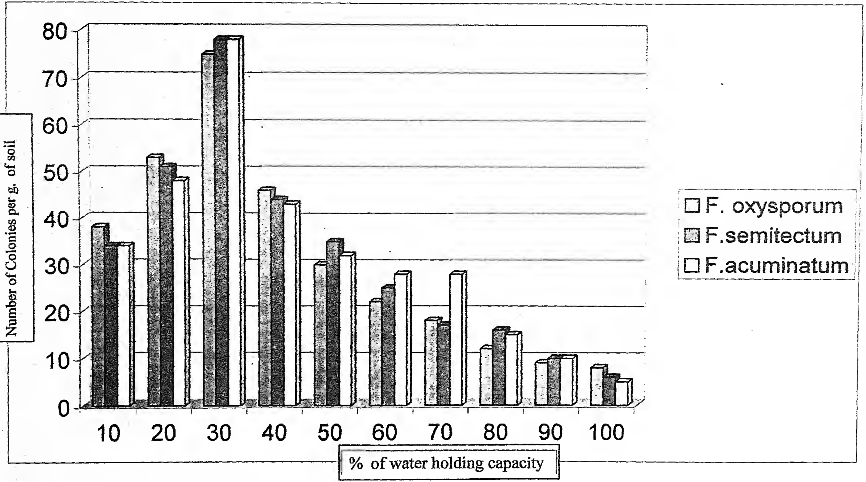
The survival of the three *Fusarium* species was maximum when soil moisture was maintained at 20 and 30% water holding capacity.

TABLE - 4

Effect of soil moisture on the survival of *Fusarium* species

	Number of colonies per 50 g. of soil		
% of water holding capacity of soil	***F. oxysporum***	***F. semitectum***	***.F acuminatum***
10	38	34	34
20	53	51	48
30	75	78	78
40	46	44	43
50	30	35	32
60	22	25	28
70	18	17	28
80	12	16	15
90	09	10	10
100	08	06	05

Effect of Soil moisture on the Survival of *Fusarium species* :



colonies

EFFECT OF CARBON SOURCES

Carbon occupies a very important place in fungal nutrition and has to play a pivotal role in their metabolism. Protoplasm, enzymes, cell – wall and reserve nutrients stored within the cells are composed of carbon. All the important components of cell – wall are made up of cellulose, chitin and different pectic substances which contain carbon in distinct forms and concentrations. The organic compounds, thus, not merely provide the structural frame – work of the fungal cell but they accomplish still more significant functional role of meeting the various energy requirement of the organism during its life – cycle. Dry mycelium of fungus contains about 40 to 50 percent carbon.

The pathogenic *Fusarium* species survive in soil through chlamydospores. New infections are caused by germination of these spores. An exogenous source of carbon is required in soil for formation and germination of these chlamdospores.

As carbon has an important place in the nutrition of micro organism it was considered desirable to study the effect of various carbon sources on the survival in soil of the three *Fusarium* species under investigation.

Monosacchrides usually are easily as similable form of carbohydrates among which glucose has been reported to be the most efficient source of carbon and energy for most of the fungi. Sucrose which is a major suger components of photosynthetic plants has generally been reported to be a good carbon source for plant pathogenic fungi (Tandon, 1967). Sucrose is converted into glucose and fructose before utilization.

Cellulose is the most abundant natural organic compound and comprise about one third of all vegetable matters. Fungi play a major role in the decomposition of cellulose. A long list of fungi capable of cellulose degradation has been compiled by Siu (1951).

Many fungi have been found to grow on chitinous material in soil (Skinner and Dravis, 1937) but no attempt has been made to evaluate the nutritional efficiency of chitin and mode of its utilization by fungi in – vitro.

Starch is generally found as a storage compound in green plants. Majority of fungi utilize this polysaccharide with high degree of efficiency through amylase activity.

Sequeira (1962), Green et al. (1968), Sneh et al. (1971), Schippers et al. (1972), Dhingra and Sinclair (1975), Kannaiyan and Prasad (1976), Singh and Bhargava (1981) and khati et al. (1983) for the fungi investigated by them, have found that in soils amended with carbohydrates either the number of spores is reduced greatly or the fungus is totally eliminated. Similarly, Garrett (1938) reported a decline in the viability of mycelium of Ophiobolus graminis in soil amened with glucose. According to west and Hildebrand (1941), incorporation of glucose in soil eliminated the fungi involved in Strawberry root – rot. Mitchell and Alexander (1961) as well as Buxton et al. (1965) investigated effect of chitin in the biological control of *Fusarium* diseases. Khalifa (1965) observed biological control of *Fusarium* wilt of peas by organic soil amendments. In the present study, saprophytic survival of the three *Fusarium* species has been studied up to 4th weeks. The results are presented in Table 5.

TABLE - 5

Effect of Carbon Sources on the survival of *Fusarium* species in soil.

Fusarium Species	**Treatment**	**Number of *Fusarium* colonies after treatment.**		
		1st week	**2nd week**	**3rd week**
F. oxysporum	Glucose Surcrose Starch Control	98 64 32 60	40 42 21 61	04 02 17 65
F. semitectum	Glucose Surcrose Starch Control	80 74 30 75	48 15 15 51	10 04 08 75
F. acuminatum	Glucose Surcrose Starch Control	26 08 36 78	15 04 16 75	05 00 08 85

A glance at the table shows that in general there was marked decline in population of *Fusarium* species in the soil amended with glucose, sucrose and starch up to the 4th week. The number of colonies of all the three *Fusarium* species in the soil amended with glucose, sucrose, and starch up to the 4th week. The number of colonies of all the three *Fusarium* species declined in soil amended with sucrose. Maximum number of colonies of F.*semitectum* and F. *acuminatum* were observed in soils amended with glucose, while in case of *F. oxysporum* maximum number of colonies were recorded in the soil amended with starch.

A reduction in the number of colonies was also recorded by Kannaiyan and Prasad (1976) for *Rhizoctonia solani* in the soils amended with glucose, sucrose, cellulose and starch.

EFFECT OF C : N RATIO

Fungi, like higher plants exhibit profound effect in their growth and reproductive behavior at different concentrations of carbon and nitrogen. A proper balance between these two essential elements is necessary in order to achieve satisfactory growth. The ratio suitable for one organism may not be good or as good for the other even in closely related species. This carbon and nitrogen ratio (C:N) needed for good growth of an organism often differs from that required for its best sporulation.

The C:N ration of organic amendments in the soil is often correlated with the influence of soil – borne diseases (Huber and Watson, 1970).

Growth, sporulation and formation of resting structures of the fungi are also affected by C:N ratio. The fungus could grow, sporulate and form abundant resting structures in conditions of good C and N availability. High C:N ration increases the microbial number and activity.

Maurer and Baker (1965) observed that C : N ratio greater than 25 : 1 significantly suppresses symptoms of bean root – rot. Davey and Papavizas (1963) showed that maximum inhibition of competitive saprophytic colonization of buck wheat segments by *Rhizoctonia solani* occurred in soils receving amendment adjusted to C : N ratio 100 – 40. Selvaraj (1973) studied the effect of C : N ratio on the growth and culture characteristic of *Verticillium species* and showed that under favourable C : N ratio *Verticillium species* could grow, sporulate and form abundant resting structure that could aid the fungus to build up formidable inoculum potential in soil. With the increase of C : N ratio, Singh and Bhargava (1981) observed a decline in the population in the soil of the three species of *Fuarium* studied by them.

Phytopbhore root – rot of avocado was controlled by Zentmyer (1963) by amending the soils with alfalfa – meal a material low in C : N ratio. In the present study an attempt has been made to study the effect of different C : N ratios on the survival of the three *Fusarium* species in soil. The result have been recorded in Table 6.

Table – 6

Effect of C : N Ratio on the survival of *Fusarium* species in soil

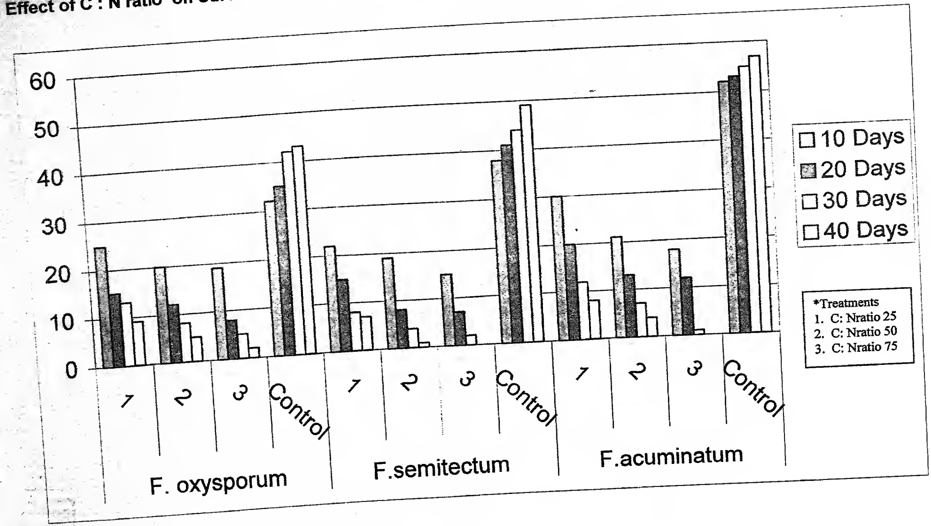
Fusarium Species	Treatment	Number of *Fusarium* colonies after			
		10 days	**20 days**	**30 days**	**40 days**
F. oxysporum	1	25	15	13	9
	2	20	12	8	5
	3	19	8	5	5
	Control	32	35	42	43
F. semitectum	1	22	15	8	7
	2	19	8	4	1
	3	15	7	2	-
	Control	38	41	44	49
F. acuminatum	1	30	20	12	8
	2	21	13	7	4
	3	18	12	1	-
	Control	52	53	55	57

Treatments

1. C : N ratio 25
2. C : N ratio 20
3. C : N ratio 75

Based on 1g glucose in air dried soil (w/w) and sodium nitrate.

Effect of C : N ratio on Survival of Some *Fusarium species* in soil :



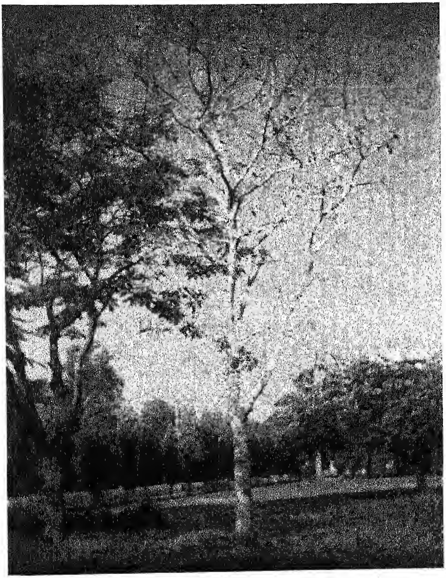
The table indicated that the population of all the three species of *Fusarium* decline in the soil samples amended with glucose and sodium nitrate mixture. It was also observed that as the C : N ratio was increased, the number of colonies fell down more rapidly in the soil.

The population of *F. acuminatum* decreased continuously with C : N ratios 25 and 50 up to the end of the incubation period. At C : N ratio 75 the decline was noticed up to the end of the incubation period. 30th day and by the 40th day the fungus was completely eliminated. The population of F.*oxysporum* and *F. semitectum* decreased with C : N ratio 25 to 50 up to the 40th day, while for C : N ratio 50 and 75 a decrease was recorded up to the 30th day and 20th day respectively. These two *Fusarium* species were completely eliminated on the 40th day with C : N ratio 50, whereas, for C : N ratio 75 the elimination was noticeable from 30th day up to the 40th day.

The population of all the three *Fusarium* species increased Continuously in the controls up to the end of the incubation period.

CHAPTER – 7

CONTROL STUDIES



CONTROL STUDIES

BIOLOGICAL CONTROL

This term means the control of a disease through some biological agency. Garrett defined biological control as any condition or practice under which or whereby survival or activity of a pathogen is reduced through the agency of an other living organism (excepting man himself), with the result that there is a reduction in the incidence of the disease cause by the pathogen. Biological interference with epidemics has been dealt with by Darpoux (1960). The mechanism of biological control of soil borne pathogens has been reviewed by Ralph Baker (1968). The first successful control of a root disease by biological means was by Millard and Taylor (1927) who reported control of scab in potatoes caused *by Streptomyces scabies* by green manuring.

Bliss (1951) successfully controlled Armillaria mellea root rot of Citrus by fumigating the soil with carbon disluphide. The fumigant kills directly and the fungus *Trichoderma viride* indirectly affects the pathogen Garrett (1958).

Wood and Tveit (1955) obtained good control of *Fusarium nivale* on oats in England with *Cahetomium cochliodes.*

Phymatorichum root rot of cotton is controlled by amending the soil with organic materials which stimulate the germination of sclerotia and thus exhaust the inoculum Mitchell et al. (1941). In the case of *Gaumannomyces graminis,* it has been suggested that the organic amendments rich in carbon

and deficient in nitrogen control the take all of wheat, Garrett (1970). Snyder et al. (1959), showed that the bean root rot was controlled by barley amendments.

Rhizoctonia root rot of snapbeans has been controlled by Papavizas and Davey (1960), Papavizas (1963) and Davey and Papavizas (1960, 1963) by amending the soil adjusted to C/N ratios with 100-40.

Mitchel and Alexander (1962) reported the control of root rot of bean by manuring the soil naturally infested by *F. solani F. phaseli* with chitin 225 kg/acre.

Root rot and wilt of Lens Culinaris by organic amendments of the soil together with the introduction of antagonists in the soil has been controlled by Mehrotra and Claudius (1972).

Biological control by a single introduced microorganism may be successfully used when the soil or plant surface is virtually free of other microorganism. Some success also has been attained by inoculating nonsterile plant propagules with antagonists.

Soil treated by steam at 100°C/3D min may be inoculated with antagonist and provide effective biocontrol of Rhizoctonia solani and Pythium ultimum, Ferguson (1958); Olsen and Baker (1968); Boadbent et al., (1971). Inoculation of the nearly sterile casing soil of commercial mushroom beds with *Psedomonas multivorans* or *P. fluorescens* has controlled brown blotch of the caps caused by *P. tolaasii,* apparently through competition, Nair and Fahy (1976).

The primary antagonist, *Trichoderma viride.* Inoculated on branch stubs with the pruning chears, has been used for control of the silver leaf disease (caused by *Stereum purpureum*) on plum trees in France, Grosclaude et al., (1973).

There is substantial evidence that an antagonist inoculated on a plant propagule may prevent infection by plant pathogens, including wilt fungi. Woltz et al. (1978) and Magie (1978) inoculated corms of three gladiolus varieties in Florida with *Fusarium oxysporum* f. sp. Gladioli (cause of yellows) and dipped them in either a spore suspension of *F. moniliforme* 'Subglutinans' M-685 or in a fungicide mixture prior to storage. *Fusarium* infected corms of two varieties planted for 2 years in a suppressive Florida red lateritic clay that had been planted to sugarcane for 150 years and contained many *Streptomyces sp.*, produced apparently healthy daughter corms. However, the corms harbored latent *F. oxysporum* f. sp. gladdioli and rotted the first year when planted in conducive sandy soil.

However in the present study a number of different type of antagonist of *Fusarium* infestatin has been observed in the lab condition. Attempts has been done to change the environmental condition so that the agro-climatic condition of Allahabad and adjoining areas could be properly simulated. In our observation it has been remarkably found that biological factor plays a significant role in the cause effect parameter of *Fusaria*l disease in different types of ornamental trees. The findings of the present studies have been listed in the table - 8.

Inoculation of flax with an a virulent race of *Melampsora lini* made the leaves resistant to a virulent race subsequently applied, Littlefield (1969).

When cuttings of susceptible tomatoes were placed in suspensions of different proportions of microconidia of *Fusarium oxysporum* f. sp. *lycopersici* and *F. sp. pisi* before planting, wilt became less severe as the ratio of pisi was increased. Heat killed spores of pisi did not produce the effect, Langton (1969). Similar results were obtained with *F. oxysporum* F.sp. melonis when muskmelon was inoculated simultaneously with virulent and nonvirulent isolates.

Inoculation of the cut surfaces of seet potato cuttings with isolates of *F. solani* a low grade pathogen that occupied the wounded surfaces, prevented infection by *F. oxysporum* F. sp. halalas and controlled *Fusarium* wilt, McClure (1951).

Dick (1974) found that a tomato cultivar resistant to *Fusarium oxysporum* f.sp. lycopersici inoculated with the weekly *pathogenic V. nigrescens* 2-9 days before inoculation with the pathogen *V. dahliae* became progressively more resistant to it (Melouk and Horner, 1975). Roots of tomato seedlings were dipped in spore suspensions of *avirulent V. alboatrum, V. tricorpus, Fusarium oxysporum* f.sp. *lycopersici*, or *F. oxysporum* f.sp. dianthi and planted in glasshouse benches of soil infested withvirulent *V. dahliae.* However, only a fair degree of control of veriticillium wilt was obtained under commercial conditions.

Pseudomonas syringae produces toxins *in-vitro* that are inhibitory to *Ceratocystis ulmi*, the cause of Dutch elm disease, Myers et. al. (1978).

It is well known, Kreutzer and Baker, (1975) that some bacteria that are saprophytes or pathogens of low virulence occur quite commonly in the vascular elements of plants, causing minimal injury, particularly to trees. These microorganisms seem to provide no useful defense against vascular pathogens.

The following cultures of antagonists were used for *in-vitro* test against pathogenic *Fusaria* causing wilt of ornamental trees.

1. *Chaetomium globosum* Kunze ex Fr.
2. *Chaetomium arcuatum* Rai and Tiwari
3. *Cladosporium oxysporum* Berke and Curt
4. *Myrothecium rodium* Tode ex Fr.
5. *Stachybotrytis atra* Corda
6. *Trichoderma viride-2 isolate-4*, CMI, New, Survey England.
7. *Trichoderma viride-3*
8. *Trichoderma viride-4*
9. *Trichoderma hamatum*

In the present investigation, biological control of wilt diseases of ornamental trees was undertaken. The following aspects were taken for the present study.

1. *In-vitro* testing of antagonists against three pathogenic *Fusarium* sp. viz. *Fusarium oxysporum*, *F. acuminatum*, and *F. semitectum.*

2. Testing selected antagonists through seed treatment and soil application.
3. Studying the mode of action of antagonists against *Fusarium* sp.
4. Studying the effect of plant extracts on the growth of the pathogens.

The antagonistic effect of fungi against three pathogenic *Fusarium* sp. was assessed by dual culture method on PDA medium (Dennis and Webster, 1971c).

A 9 mm disc of antagonistic effect and fungi against three pathogenic *Fusarim* sp. was assessed by dual culture method on PDA medium (Dennis and Webster, 1971 c). A 9 mm disc of antagonist was placed at one end of the petridish over the PDA medium and incubated for 48 hours at room temperature (28±2°C). Just opposite to the antagonist a 9 mm disc of pathogen was placed at 48 hours. The zone of inhibition was measured and pathogen after 24, 48, and 72 h. From these the most effective fungal antagonists were selected for further studies.

Spores of above antagonists were harvested from the PDA medium after 14 days of incubation period. The spores ere suspended in sterile distilled water, blended and filtered through a muslin cloth. The filtrate containing conidia was centrifuged at 3000 rpm for 10 min. The spernatant was discarded and the conidial pellet was resuspended in sterile distilled water. The process was repeated once again and finally the conidia were suspended in 10 ml. Of 0.1 percent carboxy methyl cellulose solution. The spore concentration of the suspension was adjusted to 4.5 to 5.8 x 109 conidiea per ml using a haemocytometer.

Cultures of above antagonists were multiplied on wheat bran peat soil medium (sivan et al., 1984). This medium was preapred by mixing wheat bran and peat soil at the ratio of 1:1 (v/v), moistened up to 40 percent level and filled in 500 ml; Ehrlenmeyer flasks. They were sterilized in an autoclave for 1 h at 1.41 kg/cm2 pressure for three successive days. This medium was inoculated with a 9mm disc of above antagonists. The flasks were incubated at room temperature at room temperature fo 14 days. The inoculum was mixed with the soil at the rate of 5g per kg of soil.

Antagonists were inoculated in the soil five days prior to the addition pathogen inoculum and the pathogen inoculum was inoculated one day prior to seed sowing.

Result observed the table that *Trichoderma viride* checked the all three species of *Fusarium* colonies but *T. viride-3* and *T. viride*-3 were moderately effective two species of *Fusarium* except *Fusarium acuminatum*, but no, effect observed other antagonists.

Effect of Leaf-Extract of some plants on Spore-germination

Under an exclusive study attempt has been done to use biological products to control the disease caused by *Fusarium*. Leaves of several plants have been reported to possess constituents toxic to various microorganism. These infect serve as a chemical protective barrier to infection in nature. Shekhawat and Prasad (1971) experimented with leaf-extract *of Melia azadirachta, Ocimum sanctum* and *Allium sativum* against 41 species of the pathogenic fungi. They found that *Curbularia penniseti* and *Helminthosporium* species failed to germinate, in leaf extract of either *Melia*

or *Ocimum*. Khanna and Chandra (1972) have reported antifungal properties of some plant extract against *Alternaria alternata* causing leaf-spot diseases of wheat. Mishra et al. (1974) reported complete inhibition of spore germinatin of *Curvularia lunata* and *Helminthosporium graminicola* in the leaf-extract of *Melia* and *Ocimum* respectively.

To study the effect of these leaf extracts on spore germination of *F. oxysporum*, F. *acuminatum*, and *F. semitectum*, the filtrates were centrifuged for ½ hour at 2000 rpm. The extracts were diluted to 50%, 100% and Hoffman's (1860) method was followed for the study of spore germination. Results on the spore germination were recorded after 24 hours of the treatment and are presented in Table 9.

It is evident from the table that out of five medicinal plant tried leaf-extract of Neem garlic and onion at 100% concentration completely checked the spore germinatin all the three *Fusaria*. In comparison to the above leaf-extract spore germination of *F. oxysporum*, F. *acuminatum* and *F. semitectum* was 95, 95 and 92 respectively in control sets (distilled water).

Spore suspensions were made in the supernatant concentrations viz. 100% and 50% and the percentage germination of the spores was recorded after their initial time (after 5 hours of the treatment) of germination. Result obtained presented in the Table.

Leaf extracts of some medicinal plants yielded satisfactory results in the present study. Leaf extracts of *Stychnos nuxvomica, Allium cepa, Azadirachta indica, Ocimum sanctum* and *Allium sativ*um at 100%

concentration completely inhibited the spore germination of all the 3 *Fusaria*, six plant species were screened for their antifungal properties.

Table : 7

Effect of antagonists on pathogenic *Fusarium* population per gram soil.

S. No.	Name of antagonists	Pathogenic Fusaria (No. of colonies per gram of oil)		
		F. oxysporum	*F. semitectum*	*F. acuminatum*
1	*Chaetomium globosum*	41	47	50
2	*Chaetomium arcuatum*	45	49	53
3	*Colletotrichum state*	58	57	54
4	*Myrothecium rodium*	51	53	48
5	*Stachybotrys atra*	51	53	48
6	*Trichoderma viride-2*	07	05	00
7	*Trichoderma viride-3*	00	00	00
8	*Trichoderma viride-4*	04	02	00
9	*Trichoderma hamatum*	05	06	00

Results observed the above table that *Trichoderma viride-3* checked the three species of *Fusarium* colonies but *Trichoderma viride-2* and *Trichoderma viride-4* were moderately effective for three species of *Fusarium* except *Fusarium acuminatum*, but no effect observed other antagonists.

Table : 8

Showing effect of leaf-extract of various medicinal plants on spore germination of *Fusarium*

S. No.	Leaf Extract	Concentrations	Percentage spore germination		
1	*Strychnos nuxvomia*	50 100	66.07 44.6	63.19 31.51	83.07 44.6
2	*Allium cepa*	50 100	20.66 0.0	20.7 0.0	25.98 0.0
3	*Azadirachta indica*	50 100	25.07 0.0	19.06 0.0	20.0 0.0
4	*Ocimum sanctum*	50 100	58.6 32.6	55.6 36.5	57.8 35.5
5	*Allium sativum*	50 100	10.0 0.0	15.8 0.0	15.87 0.0
6	Control	--	96	92	95

Leaf-extracts of some medicinal plants yielded satisfactory results in the present study. Leaf-extracts of , *Allium cepa*, *Azadirachta indica*, and *Allium sativum* at 100 percent concentration completely inhibited the spore germination of all the three *fusaria*, five plant species were screened for their antifungal properties.

CHAPTER – 8

DISCUSSION AND CONCLUSION

Discussion and Conclusion

"As Society grows geometrically, its complexity grows geometrically and its constraints grows geometrically. Sometimes one wonders if society will constrain itself one day into oblivion like the dinosaur. Agriculture and forestry are constrained like every thing else and as they go, so goes plant pathology".

-Horsfall and Cowling (1977)

There are various kinds of gardens and they are named according to their characteristic features like rock garden, water garden, wild garden, terrace garden, kitchen garden and formal garden. Kitchen gardens can be made both outdoors and indoors. Combinations can also be made, for example, a rock garden can be built in one corner, and the rest of the garden can be carpeted with a lawn, edged by flowerbeds.

The Lawn is the most important feature of any garden, as it covers nearly the entire area, and a well kept lawn is the redeeming feature of any garden.

A Rock Garden may be built to look like a mountain or a hill. Whatever is the shape, the rock garden should look natural and have planting pockets drainage. The rocks should be buried two-thirds in the ground and the visible portion should look like a natural outcrop.

Plants suited for rock gardens are small shrubs and bulbous plants like freesia, narcissus and zephyranthes; annuals with low lying branches, creepers and succulents.

A Water Garden provides a refreshing change and gives a special quality to any garden. A stream, pond or waterfall is very soothing and attractive. If a pond is a part of the garden, fish and water lilies can be grown in it. Fish also serve the purpose of eating the larvae of mosquitoes, which breed in stagnant water, Fountains can be added to enhance the beauty of the garden.

Different plants have different needs for light. Many, like the Money plant, Monstera Aspidistra, and other shade loving plants, thrive well in areas with no direct sunlight and where only naturally reflected light is available. On the other hand, many trees, shrubs and vegetables need direct sunlight.

Watering needs differ from plant to plant, and stage to stage of plant growth. Cacti and succulents have sufficient water reserves in their stems and leaves, and do not lose much moisture as compared to other plants, making them easier to maintain. In fact, excess watering is the chief enemy. Many such plants die from enthusiastic over-watering. This is because the air spaces between the soil particles are displaced by water, and if this persists over a period of time, the roots are deprived of oxygen and are liable to rot from fungal attack.

All trees must be planted on the north or west side of the garden. If planted on the east or south, the trees will throw a shadow over the garden and prevent grass and other sun-loving plants from growing properly. Some of the trees suited for small to medium size gardens are *Bauhinia* (kachnar), Bottlebrush, *Plumeria* (champa) Peach Blossom, Pine and Bottle palm.

The best time for planting trees is during the rainy season. For large trees the pit should be about one metre in depth and diameter and smaller pits for smaller trees. Pits should be dug two to three months before planting. The soil should be mixed with organic manure (30 percent) and 2-3 handfuls of bone-meal or 2-3 tablespoons of S. superphate and then allowed to settle. Pressure of falling rainwater facilitates soil settling. The saplings should thenbe planted on in each pit.

Plant diseases are caused by many organisms, such as bacteria, virus, fungus and insects. Leaf and stem diseases are the result of bacteria, virus and fungal infections; whereas soil-borne disease affecting the roots are transmitted by various fungi and nematodes. The plants also get sick due to environmental factors, such as air water; pollution, deficiency or excess of nutrients or sunlight and the wrong kind of climate.

Fungal diseases are quite common and are encouraged by atmospheric humidity, dew and reduced light conditions, such as on over case days. Fungus sreads over the entire plant, damaging its appearance and maturity. Common among fungal infections is powdery mildew, which appears as a white or grey powdery coating on leaves, tender stems or flowers buds. These turn reddish afterwards.

Soil condition influences occurrence of soil-borne diseases during periods between susceptible crops. If the soil condition is favourable to the development of disease the amount of infections material left behind in the soil for infection of the next susceptible crop is much increased. According to Garrett (1973), a root pathogen can be a successful saprophyte in soil

Fungi are present in soils of both cultivated and non-cultivated fields and some of them are well known as wild causing pathogens. In the present study isolations from different fields of Allahabad and its adjacent regions carrying fruit and ornamental plants constantly yielded species of *Fusarium* besides a number of other fungi. Sinch *Fusaria* are well known as wilt causing pathogens, ecological factors governing their distribution in six selected fields of Allahabad and Botany Department, garden Allahabad University. viz. Agricultural Institue, Naini, C. S. Azad Park, Allahabad, were studied. The soil samples from the above fields were collected monthly for one complete year. The data revealed much variation through the three years but no significant difference was noted in number of colonies isolated from three different areas in a particular month. The soils of all the three fields were found to be sandy loam (Gangetic alluvial). It was observed that soil of all the three fields contain maximum number of *Fusaria* during October and it was interesting to note that the soil conditions as well as climatic conditions were optimum and comparatively better than the other months.

The rhizosphere mycoflora was different both qualitatively and quantitatively from the non-rhizosphere in all the seasons which agrees with the findings of Timonin (1940), Roy et al (1980) and Antique et al. (1982). An increase in the number of rhizosphere fungi is perhaps due to "rhizosphere effect" (Hiltner, 1904; Rouatt and Katznelson, 1961; Antique et al. 1982). The fluctuation in fungal spp. In the non-rhizosphere and rhizaosphere region may be due to deaphic factors viz., soil moisture, pH,

temperature, organic matter etc. (Aelxander, 1977; Mueller-Combois and Parera, 1971. Soil texture and pore space between soil particles also affect the growth of fungi and microorganisms (Shaw, 1952, Luthin, 1957; Russel, 1967, Christensen and Whittingham, 1965; Bahera Narain and Mukherji, 1984).

Controversial views have been reported regarding the distribution of soil fungal flora in different seasons. According to Christensen (1969), Marinez and Ramirez (1979), Saksena et al. (1967) there is seasonal variation in the distribution of soil fungal flora. Gams and Domsch (1969), and Soderstrom (1975) have reported that seasons did not affect the quantitative as well as qualitative variations in the soil fungal flora.There is increase in the fungal population in rainy season as the moisture content increased (Warcup, 1957). The density of fungal population increases in rainy season due to sufficient relative humidity resulting in an increase in the moisture level of soil. In the present study, similar pattern was found. The fungal population increased in the rainy season and decreased in summer. It may be due to low moisture level of soil increases and decomposition of organic matter starts rapidly and fungi are encouraged for growth and sporulation. Gradual decrease in fungal population starts in winter due to the (a) decrease in soil moisture and (b) temperature.

The number of fungi decreased with increase in the soil depths. The reduction in number of fungi with increasing soil depth may be due to the reduction in organic matter and oxygen, and increased carbon dioxide, *Penicillia, Trichoderma, Aspergilli* and *Fusaria* seem to tolerate the

fluctuations in environmental conditions as they were found almost in all the soil samplings in the present study. They have been reported to be most tolerant ones to the adverse conditons (Rai et al., 1970; Dubost, 1962; Phanasenko, 1967). Hence it may be concluded that these antagonists have wide ecological spectrum. The dominance of *Penicillia, Aspergilli, Fusaria* and *Trichoderma* in the present study agrees with the reports of Upadhyay and Rai (1979).

Generally the population of micro-organisms declines with an increase in depth of soil profile. The root system of plants favours the growth of microbes by excretion of nutrient substances (Krasilnikov, 1958). Similar plea about the distribution o micro-organisms at various depth has been given by Jayasheela and Oblisami (1975) but they reported that the rhizosphere effect increased with increase in depth. The population of these mciro organism differs quantitatively, qualitatively (Katznelson et al., 1948 and physiologically (Rouatt and Katznelson, 1961).

Soil-borne fungal pathogens are influenced by soil water factor which is an important factor for better growth and survival of such. The propagules of saprophytic and pathogenic fungi survive in the root region of plants in adverse conditions by colonizing organic debris and producing chlamydospores and sclerotia.

A number of *Fusaria* were found from the soil of various orchards and studies on their orphological characters indicated that they were isolates of *F. oxysporum, F. semitectum* and *F. acuminatum*. Pathogenicity test of these isolates revealed that all the ornamental plants caused wilting. The

incidence of wilting in relation to different soil and composition was studied and the highest percentage of wilting was observed in the pots containing sand only by all the pathogens, while the lowest in pots containing soil only.

Soil is a resting place for a wilt pathogene and it is primary source of inoculum for on set of plant disease. Our knowledge regarding factors affecting survival of various wilt and root-rot causing organisms is however, very meagre. A number of soil factors like temperature, moisture and amendment affect the population of pathogen and thus regulate the severity of infection. Creating unfavorable conditions for the pathogens either by regulating the temperature, soil moisture and amending the soil with chemicals will help in controlling many diseases. The present study, dealing with the effect of some factors on the survival of species of *Fusarium* in soil, indicate that lowering or raising the temperature of soil or by increasing the soil moisture, the wilt of ornamental trees can be controlled to some extent. The population of *Fusaria* was considerably reduced at low or high temperature and high soil moisture. As it has been suggested by Norton (1953), Kapoor (1954) and Dhingra and Sinclair (1975). The reduction of *Fusarium* species population at high soil moisture level may be attributed to increase bacterial activity in turn may result in the lysis and the digestion of fungal mycelium and spores.

Amendments of soil with certain carbon sources also decreased the *Fusarium* population. Amongst glucose, sucrose and starch, sucrose was found to be most effective in reducing the *Fusarium* population in the soil. Soil amended with ammonium sulphate and urea also lowered the

population of present *Fusaria*. Furthermore, it was interesting to note that an increase in C:N ratio of soil i.e. 80, the *Fusaria* were either completely eliminated or a very low number of colonies persisted. It may therefore be reduced that amendment of soil either with sucrose, ammonium sulphate and urea by increasing the C:N ratio, the wilt ornamental trees at an early stage could efficiently be controlled.

Thus on the basis of results obtained it is possible to check the population of three species of *Fusarium* in the soil as well as in controlling the wilt of mango, guava, aonla, crotons, palm and thuja at seedling stage.

Biological control must work within the context of biolgoical balance. The soil is more stable then the aerial environment in practically all respects, but it can be slowly altered by many conditions.

The studies discussed in this section suggest that chemicals may achieve disease control by nudging the microbiological blance rather than directly killing the pathogen.. This could open a new era of plant disease control, even as sulfanilamide and penicillin changed medical practice from killing human pathogens with poisons to inhibiting them with antibodies.

Biological control by a single introduced micro-organism may be successfully used when the soil or plant surface is virtually free of other micro-organisms. Some success also has been attained by inoculating nonsterile plant propagules with antagonists.

Vascular pathogens that have breached the host defenses and reached the vascular elements are well protected from antagonists. *Pseudomonas*

syringae produces toxins in-vitro that are inhibitory to *Ceratocystis ulmi,* the cause of Dutch elm disease Myers et al., (1978)

Under an exclusive study attempt has been done to use biological products to control the disease caused by *Fusarium.* Leaves of several plants have been reported to possess constituents toxic to various micro-organism. These infect serve as a chemical protective barrier to infection in nature. Shekhawat and Prasad (1971) experimented with leaf-extract of *Melia azadirachta, Ocimum sanctum* and *Allium sativum* against 41 species of the pathogenic fungi.

Spore suspension were made in the supernatent concentrations viz. 100% and 50% and the percentage germination of the spores was recorded after their initial time (after 5 hours of the treatment) of germination.

Antagonists like *T. viride-2, T. hamatum* and *T. viride-3* exhibited greater antagonism and they differed in their mechanism of action against the pathogen. *T. viride-2* and *T. viride-3* were found to overgrow. Fusarium sp., *T. hamatum* secreted yellowish metabolites which destroyed the growth of pathogen at the zone of contact. Parasitation of antagonist was also reported by Vesely (1978b).

Soil inoculation with *T. viride*-2 effectively controlled the wilt and seed rots followed by T. *viride-2, T. viride-4* and *T. viride-3*. Among the fungal antagonists *T. viride-2* was found to be superior in reducing the wilt.

Leaf extract of some medicinal plants which were found effective during spore germination were also tried for controlling the wilt of ornamental trees at seedling stage. Neem (*Azadirachta indica*) at 100%

concentration, completely checked the spore germination of all the three *Fusarium* spp. It was further observed that leaf extract and garlic bulb extracts at 100% concentration were also proved effective to check the spore germination of test organisms.

Environmental pollution and changing climatic pattern such as excessive water precipitation and lack of nutritive substance in the soil appears to be having direct correlation on the frignency of disease incidence on the costly ornamental plants especially in the urban areas. The control of diseases thus require a cost effective approach and methods which could be adopted by replacing the traditional methods of disease management. The findings of the present work seems to be application to find out such ways and means.

CHAPTER – 9

SUMMARY

A comprehensive survey of various gardens of Allahabad, Pratapgarh, Azamgarh, Ambedkar Nagar, mau, Ballia, Ghazipur and its adjacent regions were made and various wilted ornamental trees and soil samples were collected. Blotter ,Agar Plate and Blotter Roll methods, were used for isolation of *Fusarium* species. *Fusaria* were isolated purified and maintained on malt-extract and Potato Dextrose Agar media. Morphological studies were carried out and identifications were made.

Fusaria isolated from soil samples and wilted ornamental trees at various places are as follows:

***Fusaria* isolated from various garden, soils and roots of wilted trees**

Name of Ornamental Trees	*Fusaria* isolated from soil	*Fusaria* isolated from wilted ornamental trees
Acacia auriculiformis	*F. oxysporum*	*Fusarium oxysporum*
	F. solani	*F. equiseti*
	F. equiseti	*F. fusarioides*
	F. acuminatum	*F. species*
	F. spp	*F. spp.*
	F. semitectum.	*F. sp.*
Amhesstia nobilis	*F. acuminatum*	*F. oxysporum*
	F. oxysporum	*F.acuminatum*
	F. moniliformae	*Fusarium sp.*
	F. solani	*Fusarium sp*
	F. semitectum.	
Azadirachta indica	*F. oxysporum*	*F. semitectum*
	F. equiseti	*F. monliformae*
	F. solani	*F. oxysporum*
	F. acuminatum	
	F. semitectum.	

Bauhinia verigata	*F. acuminatum*	*F. solani*
	F. solani	*F. oxysporum*
	F. semitectum	*F. semitectum*
	F. oxysporum	*F. sp.*
Bignonia megapotanica	*F. oxysporum*	*F. oxysporum*
	F. equiseti	*F. moniliformae*
	F. acuminatum	*F. acuminatum*
	F. solani	*F. equiseti*
	F. semitectum	*F. sp.*
Callistemon lamerolatus	*F. acuminatum*	*F. niveble*
	F. oxysporum	*F. sumbaein*
	F. moniliformae	*F. garminearum*
	F. cumorum	*F. sp.*
	F. semitectum	*F. sp.*
	F. sp.	
Calophyllum inophyllum	*F. leterosporum*	*F. oxysporum*
	F. species	F. solani
	F. equiseti	F. sp.
	F. sp.	F. sp.
	F. solani	F. sp.
	F. oxysporum	
	F. smitectum	
	F. acuminatum	
Cassia fistula	*F. solani*	*F. oxysporum*
	F. heterosporum	F. roseum
	F. oxysporum	F. sp
	F. smitectum	F. sp
	F. acuminatum	
	F. sp.	
	F. sp.	
Cassia maginata	*F. solani*	F. acurinatum
	F. oxysporum	F. sp.
	F. smitectum	F. sp.
	F. acuminatum	F. oxysporum
	F. stipaldes	F. sp
	F. culmorum	

	F. sp	
Cochlospermum	*F. oxysporum*	F. lateritium
gossypium	*F. smitectum*	F. anthrosporiosdes
	F. acuminatum	F. stil bodies
	F. solani	F. sp.
	F. roseum	F. sp.
	F. graminearum	
	F. poae	
Crataeva roxburghi	*F. solani*	F. oxysporum
	F. juruanum	F. moniliforms
	F. oxysporum	F. sp
	F. smitectum	F. sp
	F. acuminatum	F. sp
	F. sp	
	F. sp	
Delonix regio	*F. oxysporum*	F. larvarum
	F. smitectum	F. solani
	F. acuminatum	F. sp
	F. moniliform	F. semitectum
	F. solani	
Erythrina indica	*F. oxysporum*	F. fusaicide
	F. smitectum	*F. oxysporum*
	F. acuminatum	F. sphareal
	F. solani	
	F. sp	
	F. sp	
Eucalyptus citriodora	*F. oxysporum*	F. boxieola
	F. moniliform	F. eoncalas
	F. rasum	F. sp
	F. acuminatum	F. sp
	F. smitectum	
	F. solani	

Eucalyptua Globulus	*F. solani*	F. xylarioides
	F. fusiroidr	F. *acuminatum*
	F. oxysporum	F. oxysporum
	F. smitectum	F. solani
	F. acuminatum	
	F. sp	
	F. sp	
Ficus clastica	*F. stilboides*	*F. sulphuraum*
	F. gaminearum	*F. sambucinum*
	F. solani	*F. oxygpon*
	F. equisiti	*F. sp.*
	F. oxysporum	
	F. semitectum	
	F. acuminatum	
Ficus religiosa	*F. nivale*	*F. oxyporum*
	F. sumbacin	*F. heterosporum*
	F. solani	*F. spp.*
	F. oxysporum	*F. spp.*
	F. sp.	*F. spp.*
	F. smitectum	
	F. acuminatum	
Gardenia latifalia	*F. stilboides*	*F. literitium*
	F. eulmorum	*F. oxysporum*
	F. auenaeouno	*F. rasum*
	F. saloni	*F. spp.*
	F. equiseti	*F. sp.*
	F. oxysporum	
	F. smitectum	
	F. acuminatum	

Hibiscus populneus	*F. saloni*	*F. epistromum*
	F. roscum	*F. solani*
	F. moniliformas	*F. gigas*
	F. poae	*F. oxysporum*
	F. sp.	*F. spp.*
	F. oxysporum	
	F. smitectum	
	F. acuminatum	
Magnolia grandiflora	*F. fusiroides*	*F. oxysporum*
	F. heterosporum	*F. rascum*
	F. gigas	*F. equisti*
	F. solan	*F. spp.*
	F. sp.	
	F. oxysporum	
	F. smitectum	
	F. acuminatum	
Michelia champaca	*F. oxysporum*	*F. solani*
	F. equiseti	*F. moniliformal*
	F. solani	*F. sp.*
	F. spp.	*F. sp.*
	F. smitectum	
	F. acuminatum	
Polyalthia langifolia	*F. solani*	*F. moniliforma*
	F. oxysporum	*F. nivale*
	F. xylatioides	*F. sp.*
	F. sp.	*F. sp.*
	F. sp.	
	F. smitectum	
	F. acuminatum	
Putranjia roxburghii	*F. heterosporum*	*F. oxysproum*
	F. solani	*F. moniliformar*
	F. poal	*F. acuminatum*

	F. larvarum	*F. sp.*
	F. sp.	*F. sp.*
	F. sp.	
	F. oxysporum	
	F. smitectum	
	F. acuminatum	
Saraca indica	*F. solani*	*F. opxysporum*
	F. oxysporum	*F. moniliforme*
	F. roscum	*F. semitectum*
	F. equistal	*F. sp.*
	F. spp.	
	F. smitectum	
	F. acuminatum	
Terminalia arjuna	*F. semitectum*	*F. acuminatum*
	F. saloni	*F. heterosporum*
	F. acuminatum	*F. spp.*
	F. spp.	*F. spp.*
	F. oxysporum	
	F. smitectum	
	F. acuminatum	
Theuctia preuvisana	*F. saloni*	*F. equisiti*
	F. oxysporum	*F. acuminatum*
	F. roscum	*F. moniliformed*
	F. eonealar	*F. oxysporum*
	F. xylarioides	*F. specis*
	F. sp.	*F. species*
	F. sp.	*F. species*
	F. species	*F. species*
	F. smitectum	
	F. acuminatum	

Isolation studies revealed that out of 34 speics of Fusarium 30 speics from soil sample and 23 species from or namental wilted trees were isolated.

Pathogenicity test and percentage wilting of some ornamental trees at seedling stage.

Seedling (ornamental trees)	Organism	Percentage of seedling wilted		
		After 1 week		After 4 days in culture filtrate
		Uninjured	Injured	
Madina	*F. oxysporum*	40	50	60
	F. semitectum	50	60	90
	F. *acuminatum*	25	35	50
	Control	Nil	Nil	Nil
Ficus religiosa	*F. oxysporum*	42	52	61
	F. semitectum	55	59	90
	F. *acuminatum*	31	41	51
	Control	Nil	Nil	Nil
Thuja compacta	*F. oxysporum*	40	50	50
	F. semitectum	48	58	85
	F. *acuminatum*	30	45	48
	Control	Nil	Nil	Nil
Calistimam lesnsiolatus	*F. oxysporum*	40	50	60
	F. semitectum	50	60	95
	F. *acuminatum*	30	20	50
	Control	Nil	Nil	Nil
Palm spp.	*F. oxysporum*	43	55	52
	F. semitectum	54	65	98
	F. *acuminatum*	36	45	52
	Control	Nil	Nil	Nil
Cassia fistula	*F. oxysporum*	45	58	60
	F. semitectum	50	62	95
	F. *acuminatum*	35	48	68
	Control	Nil	Nil	Nil
Thivetia oderatum	*F. oxysporum*	50	60	90
	F. semitectum	34	42	52
	F. *acuminatum*	15	20	35
	Control	Nil	Nil	Nil

Seedling (ornamental trees)	Organism	Percentage of seedling wilted		
		After 1 week		After 4 days in culture filtrate
		Uninjured	Injured	
Eucalyptus spp.	*F. oxysporum*	45	55	65
	F. semitectum	55	65	95
	F. *acuminatum*	42	52	61
	Control	Nil	Nil	Nil
Polyalthia spp.	*F. oxysporum*	48	58	60
	F. semitectum	50	65	90
	F. *acuminatum*	45	56	65
	Control	Nil	Nil	Nil
Dalbergia sissoo	*F. oxysporum*	50	65	72
	F. semitectum	52	68	90
	F. *acuminatum*	45	58	65
	Control	Nil	Nil	Nil

Results from the pathogenicity tests revealed that among the *Fusaria* isolated three species of *Fusarium* were capable of causing seedling wilt of ornamental trees. The wilting was characterised by gradual withering, yellowing and drying of leaves. Later on it was followed by drying of entire seedlings. It was observed that there was slightly higher percentage of infection in case of injured root seedlings than those uninjured. Out of the three species *F. oxysporum* was more pathogenic to seedlings of ornamental trees than the other two species, as it caused a higher percentage of wilting in the seedlings.

Results from another set, where the seedlings were kept in culture filtrates of *Fusarium* species, showed that seedlings wilted within seven days. All the seedlings kept in culture filtrates of *F. oxysporum*, wilted while in culture filtrates of F. semitectm and F. *acuminatum* the percentage was a little less. Controls remained healthy in both set of experiments. Thus from the above experiments it is clearly evident, that *F. oxysporum*, causes more damage than other two species of *Fusarium* and from second set that some toxic substance also plays a role in causing seedling wilt of ornamental trees. An attempt was therefore made to detect the toxic substance (Fusaric acit) in the culture filtrates of the three species of *Fusarium*.

When the *Fusaria* were tested for its pathogenicity in pot culture experiments, the first symptom of the disease occurred 15 days after sowing, when the plant 6" to 9": in height, starting from yellowing of leaves and ultimately the plants wilted. The roots shreaded out due to decayihng. Dark brown lessions were observed on the sheath or collar region of the plants.

Spore morphology is the major character in the identification of *Fusaria*. Spores may be conidia produced as simple or pclyphialidic slime sores or as enteroblastic spores (i.e. a conidium produced through a pore without the involvement of the outer wall of the conidiophore and enlarging without the formation of a septum), or chlamydospores which in many species form the resting stage. Conidia may occur as 0-1 septate, pyriform, fusoid to oval microconidia through to straight or curved, 0-10 or more septate macroconidia.

Investigations on the extra-cellular production of toxins in vitro revealed that *F. oxysporum*, F. *acuminatum* and *F. semitectum* were efficacious in producing the toxins. It was interesting to note that they produced a high amount of Fusaric acid in vitro.

For many *Fusaria*, survival in soil depends on chlamydospores that have the ability to withstand adverse environmental conditions. On the basis of present study we suggest defining the chalmydospore of *Fusaria*. Chlamydospore a viable, asecually produced accessory spore resulting from the structural modification of a vegetative hyphal segment or conidial cell possessing a thick wall mainly consisting of newly synthesized cell wall material; its function is primarily survival in soil.

The present study deals with some factors affective survival of five species of *Fusarium* viz., *F. oxysporum*, F. *acuminatum* and *F. semitectum* isolated from soils and wilted ornamental trees of different places. For this Allahabad district was selected for survival studies. The soil was dried, and sieved and was infested with 3% maize meal sand culture. For the study of the effect of temperature on the survival of the present five species of *Fusarium*.

The maximum survival of all the *Fusarium* species was observed between 20°C and 25°C. Their number (colonies) decreased as the temperature was either increased or decreased. Maximum number of colonies of F. *acuminatum* and *F. oxysporum*, were observed at 25°C while in case of *F. semitectum* maximum number of colonies recorded at 20°C. At

5°C and 40°C the survival of the present fungi was minimum. No colonies, however, could be recovered at 45°C.

Effect of environmental factors on disease development revealed that by lowering and raising soil temperature and with an increase in soil moisture,*Fusarial* diseases could be controlled to some extent. This was due to reduction in *Fusarial* population and an increase of bacterial.

In vitro tests of fungal antagonists against *Fusarium oxysporum*, F. *acuminatum* and *F. semitectum*, *Trichoderma viride*-2, *T. viride*-3, *T. viride-4* and *T. hamatum* were highly inhibitory seedling raised from seeds treated with *T. viride-3*, *T. viride*-3 and *T. viride-4* produced longer roots of crops under investigation seeds treated with *T. viride-3*, T *viride*-3, *T. hamatum* and *T. viride-4*. Produced longer shoots seedlings raised from seeds treated with *T. viride-3*, *T. hamatum*, *T. viride*-3, *T. viride-4*. Produced higher dry matter seedlings raised from seeds treated with *T. viride-3*, *T. hamatum*, *T. viride*-3, *T. viride-4* were recorded higher vigorous.

Soil application of antagonists viz., *T. viride-3*and *T. viride-4* at 5 gm per Kg. Of unsterilized sick soil reduce the incidence of wilt disease. Soil application of antagonists viz. *T. viride-3* and *T. hamatum* was also superior to other treatments in controlling the wilt diseaase. Culture filtrates of *T. hamatum* and *T. viride-3* were found to effectively inhibit the growth of the pathogen. Some plant species were screened for their antifungal properties.

Spore suspension were made in the supernatant concentrations viz. 100% and 50% and the percentage germination of the spores was recorded after their initial time (after 5 hours of the treatment) of germination.

Leaf extracts of some medicinal plants yielded satisfactory results in the present study. Leaf extracts of Strychnos nux-vomica, Allium cepa, Azadirachta indica, Ocimum sanctum and Allium sativum at 100 percent concentration completely inhibited the spore germination of all the three *Fusaria*.

CHAPTER - 10

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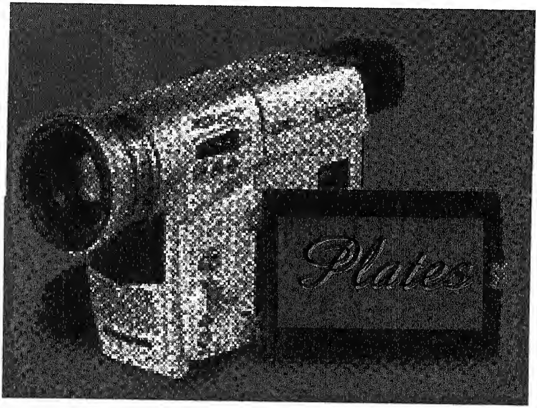
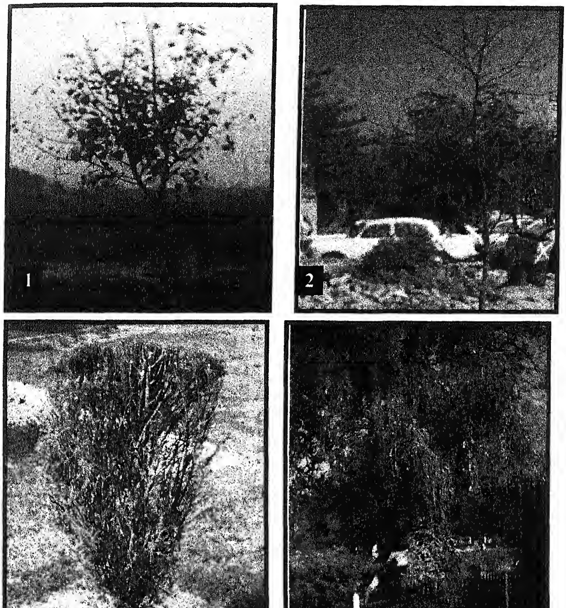
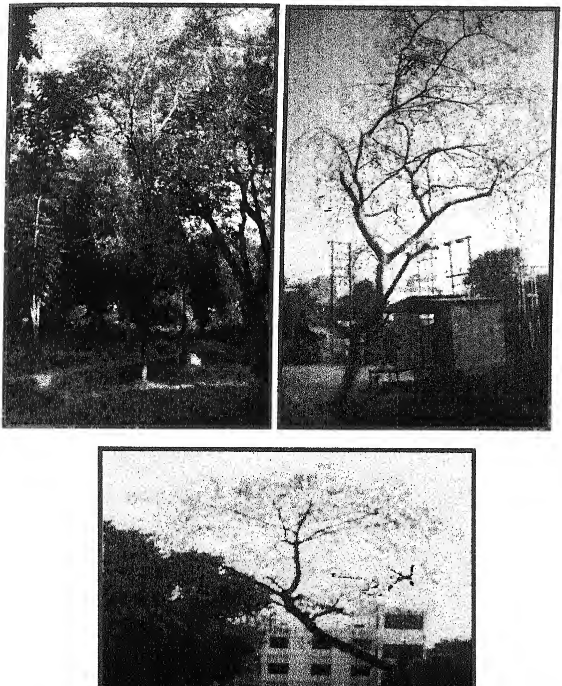

Plates

PLATE - 1



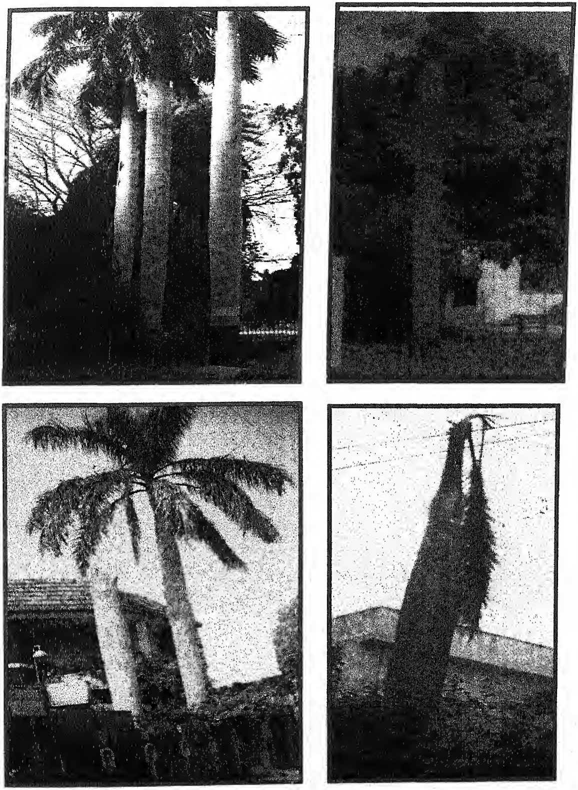
1. Wilted tree of *Ficus religiosa*
2. Wilted tree of *Mimosops elengi*
3. Wilted plant of *Thuja compacta*
4. Wilted tree of *Calistimam lensiqlatus*

PLATE - 3



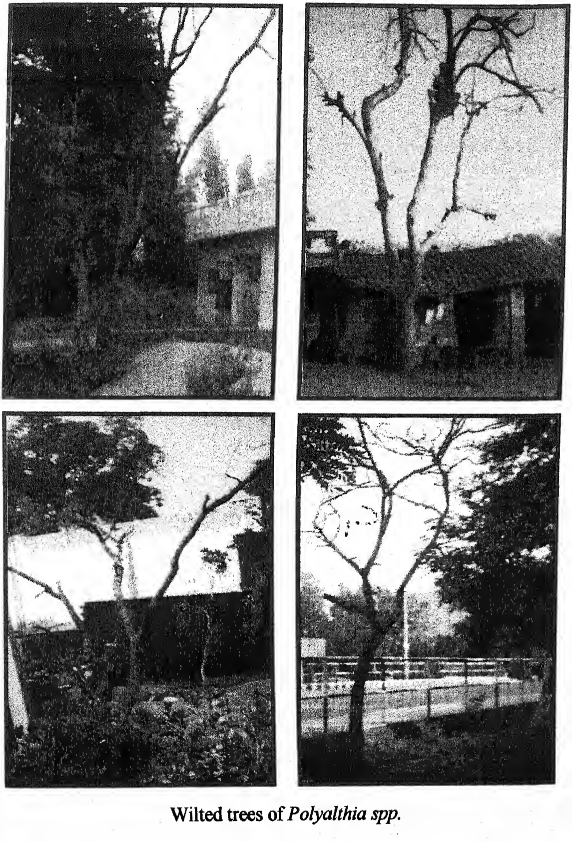
Wilted trees of Shisham (*Dalbergia sissoo*) caused by *Fusarium solani*

PLATE - 5



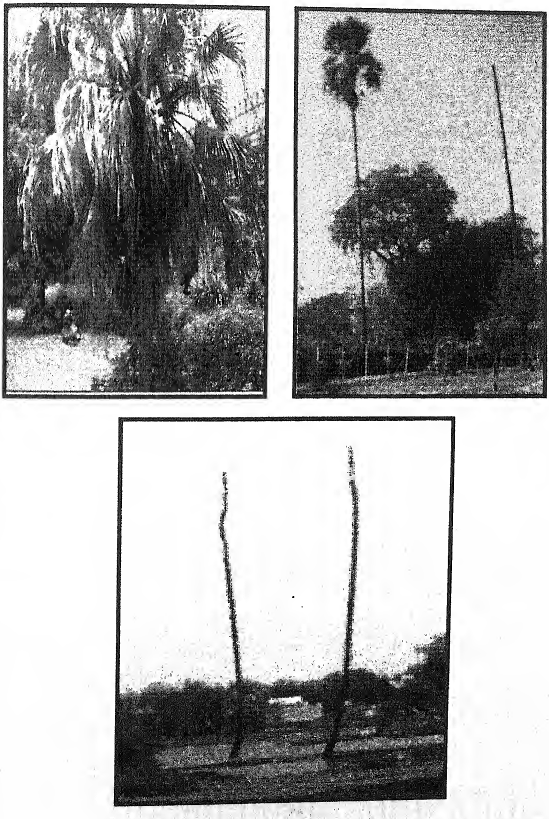
Wilted trees of Bottle Palm

PLATE - 6



Wilted trees of *Polyalthia spp.*

PLATE - 8



Wilted trees of Palm (*Borossus flabelifommis*)